APPLYING EVIDENCE-BASED GUIDELINES TO LOWER HEART FAILURE ADMISSIONS

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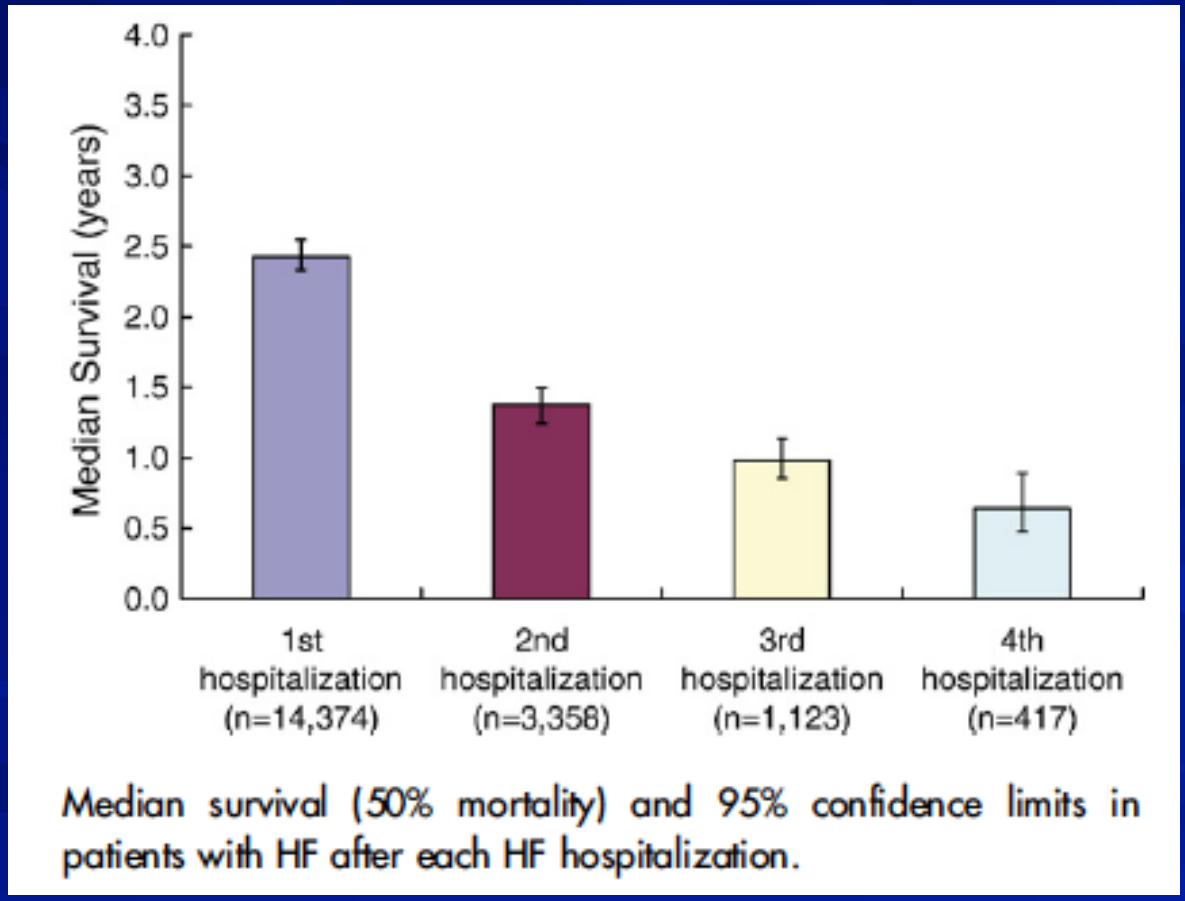
DISCLOSURES

- NOTHING TO DISCLOSE

HF READMISSION – ADVERSE PROGNOSTIC SIGN



Median survival (50% mortality) and 95% confidence limits in patients with HF after each HF hospitalization.

In a patient cohort from British Columbia hospitalized with HF (n=14374)

Setoguchi S et al. Am Heart J 2007;154:260-6.

LACK OF MORTALITY BENEFIT IN PHARMACOLOGIC THERAPY IN ACUTE DECOMPENSATED HF

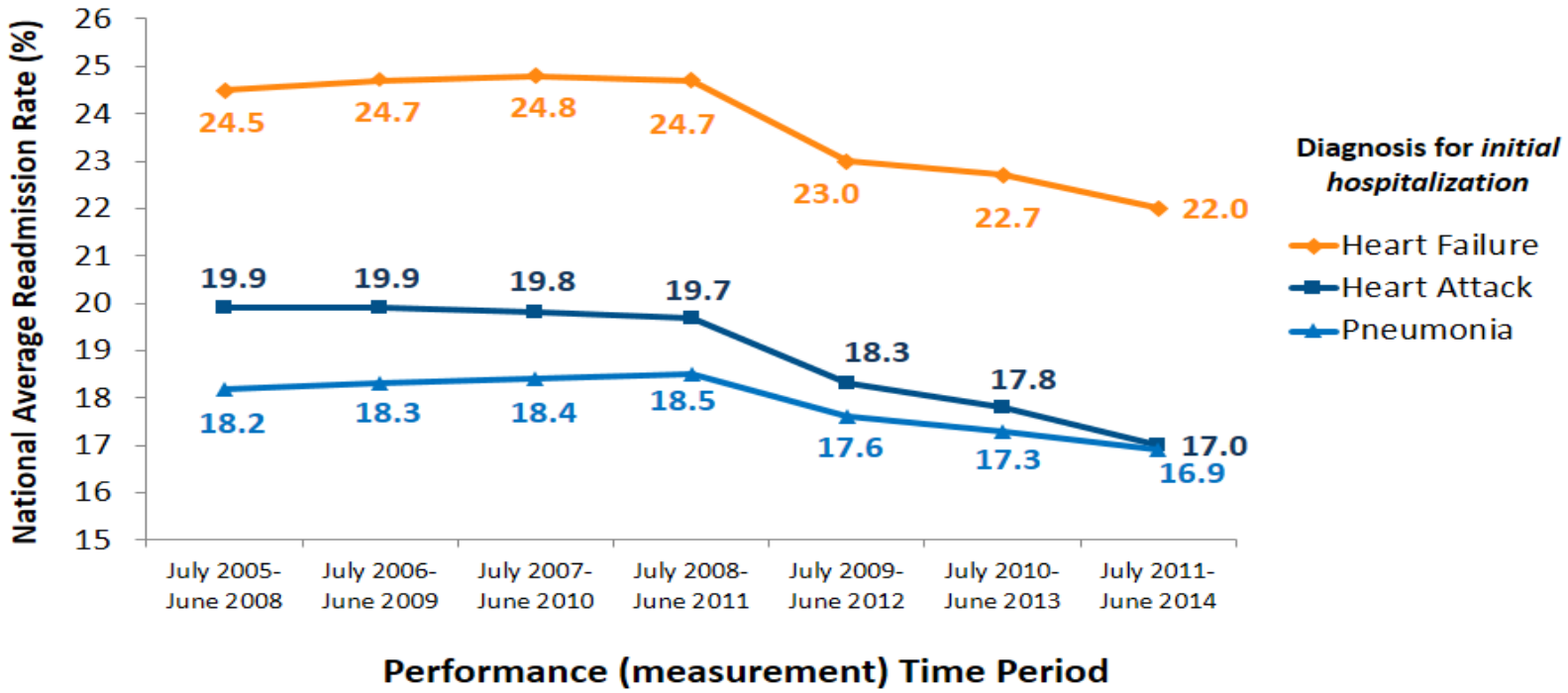
Table 1
Acute decompensated heart failure studies with dyspnea changes and outcomes endpoints

Study	Endpoint	Number of Patients (%)		P value
		Study Drug	Placebo	
EVEREST[6] **(Tolvaptan)**	Change in dyspnea at 1 day (improved)	1835 (74.3)	1829 (68)	<0.001
	All-cause mortality*	537 (25.9)	543 (26.3)	0.68
ASCEND[8] **(Nesiritide)**	Improvement in self-assessed dyspnea at 24 hours	2384 (68.2)	2320 (66.1)	0.007
	30 day death/heart failure re-hospitalization	321 (9.4)	345 (10.1)	0.31
PROTECT[7] **(Rolofylline)**	Success†	551 (40.6)	244 (36)	0.04
	Mortality at 180 days	243 (17.9)	118 (17.4)	0.82
RELAX-AHF[4] **(Serelaxin)**	Markedly or moderately improved Likert scale dyspnea	389 (68)	362 (63)	0.0865
	Days alive out of hospital up to day 60	281 (48.3)	277 (47.7)	0.37

Patel S and Pina IL. AJC 2014;114:1923-9

Figure 2

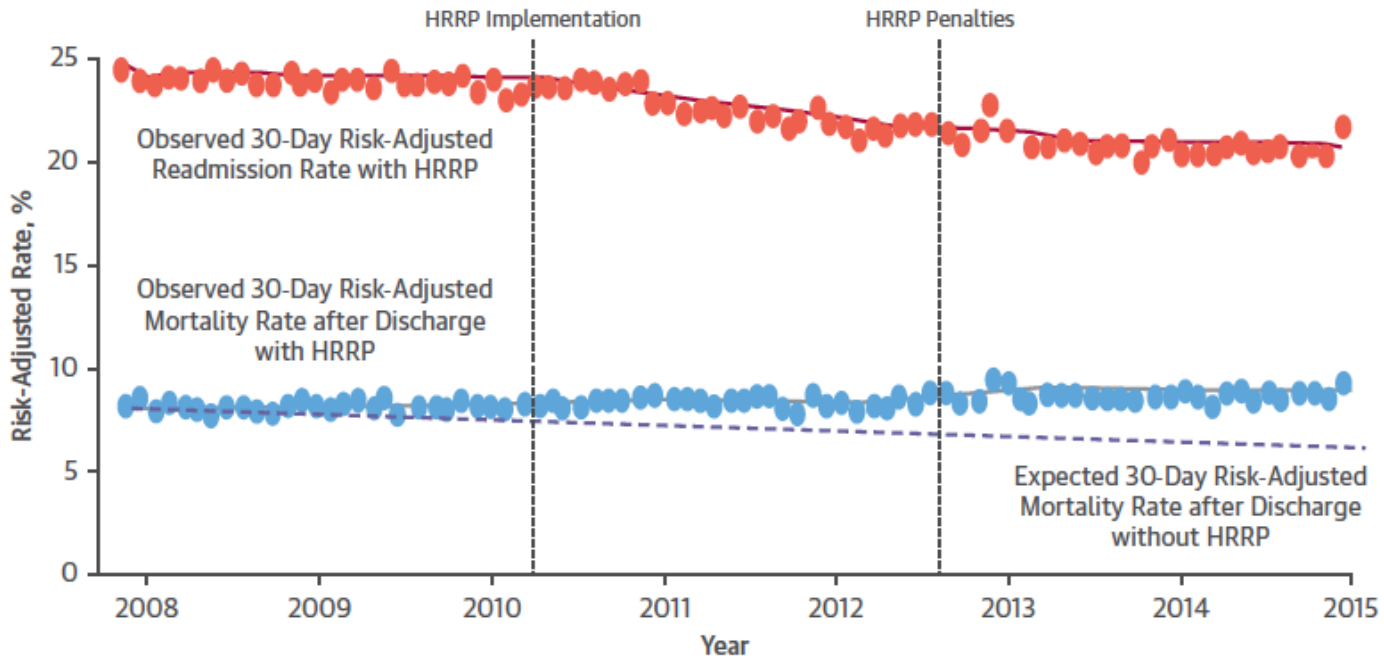
National Medicare Readmission Rates Started to Fall in 2012



Notes: National readmission rates include unplanned hospitalizations for any cause within 30 days of discharge from an initial hospitalization for either heart failure, heart attack, or pneumonia. Readmission rates are risk-adjusted for certain patient characteristics, such as age and other medical conditions.
Source: Kaiser Family Foundation analysis of CMS Hospital Compare data files.

THE HENRY J. KAISER FAMILY FOUNDATION

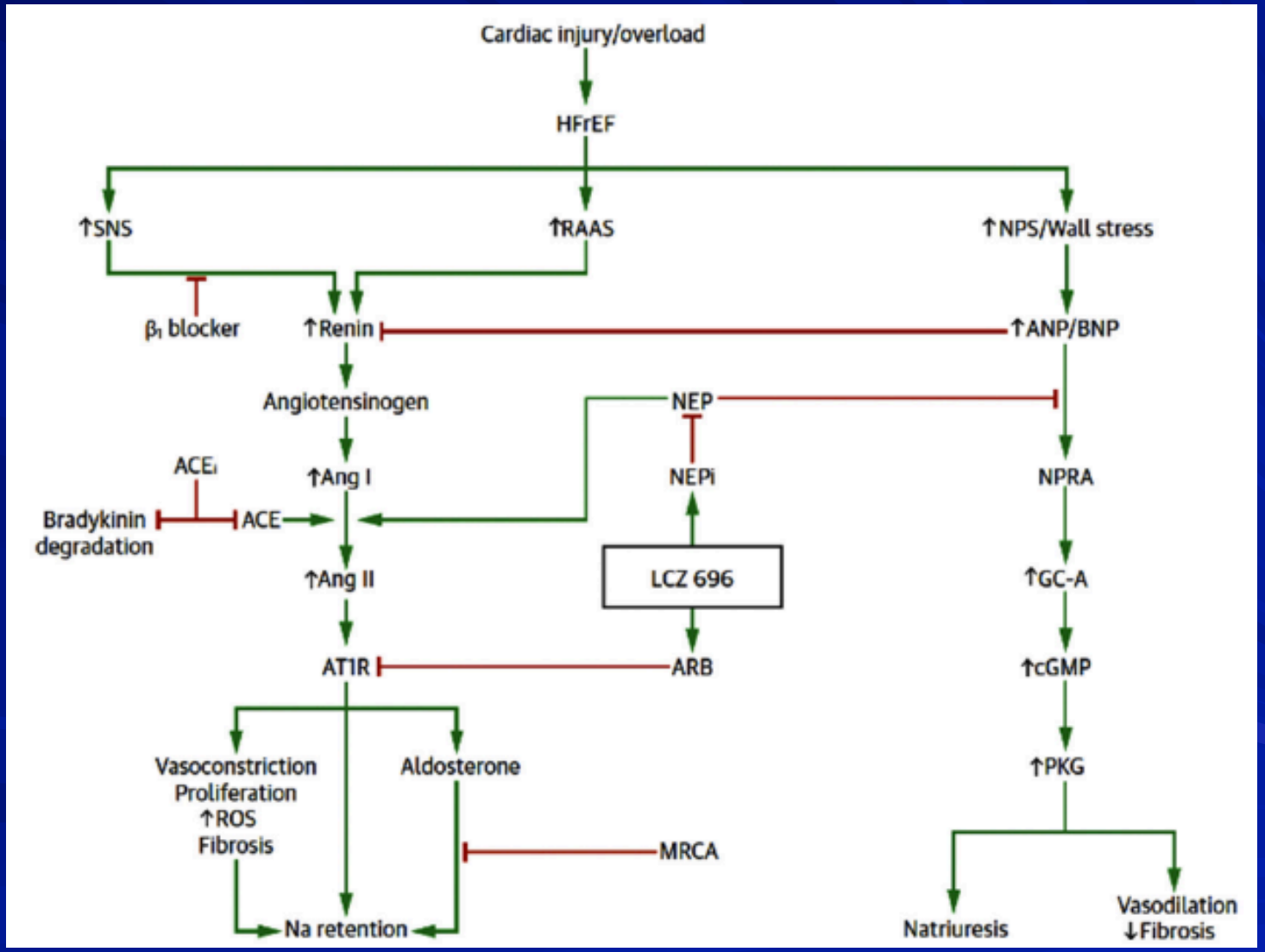
https://www.kff.org/medicare/issue-brief/aiming-for-fewer-hospital-u-turns-the-medicare-hospital-readmission-reduction-program/



	Year							
Outcomes	2008	2009	2010	2011	2012	2013	2014	Delta
30-Day Risk Adjusted Readmission with HRRP	23.5%	23.5%	23.4%	23.0%	22.5%	21.6%	21.4%	-2.1%
30-Day Mortality after discharge with HRRP	7.9%	8.1%	8.4%	8.7%	8.8%	9.1%	9.2%	+1.3%
30-Day Mortality after discharge without HRRP	7.9%	7.8%	7.5%	7.2%	7.0%	6.7%	6.6%	-1.3%

Fonarow GC et al. JACC 2018

PATHWAYS IN CHRONIC HF



Owens AT et al. Circ Res 2016;118:480-95

The New England
Journal of Medicine

Volume 325 AUGUST 1, 1991 Number 5

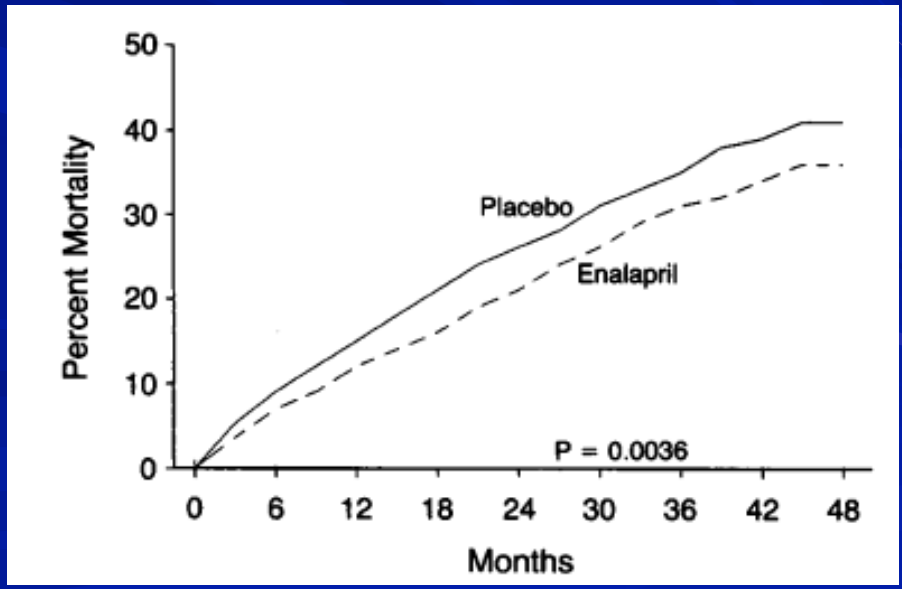
EFFECT OF ENALAPRIL ON SURVIVAL IN PATIENTS WITH REDUCED LEFT VENTRICULAR EJECTION FRACTIONS AND CONGESTIVE HEART FAILURE

THE SOLVD INVESTIGATORS*

Drug therapy		
Digitalis	68.2	65.7
Diuretics	85.3	85.6
Potassium-sparing diuretic	9.1	9.2
Vasodilators		
Any	52.4	49.7
Nitrates	43.8	39.6
Others	14.8	15.2
Antiarrhythmic drugs	20.8	22.8
Beta-blockers	7.0	8.3
Calcium-channel blockers	32.4	29.4
Anticoagulants	15.9	15.8
Antiplatelet agents	34.0	32.9
Potassium supplements	48.8	51.5

*To convert to micromoles per liter, multiply by 88.4.

†NYHA denotes New York Heart Association.



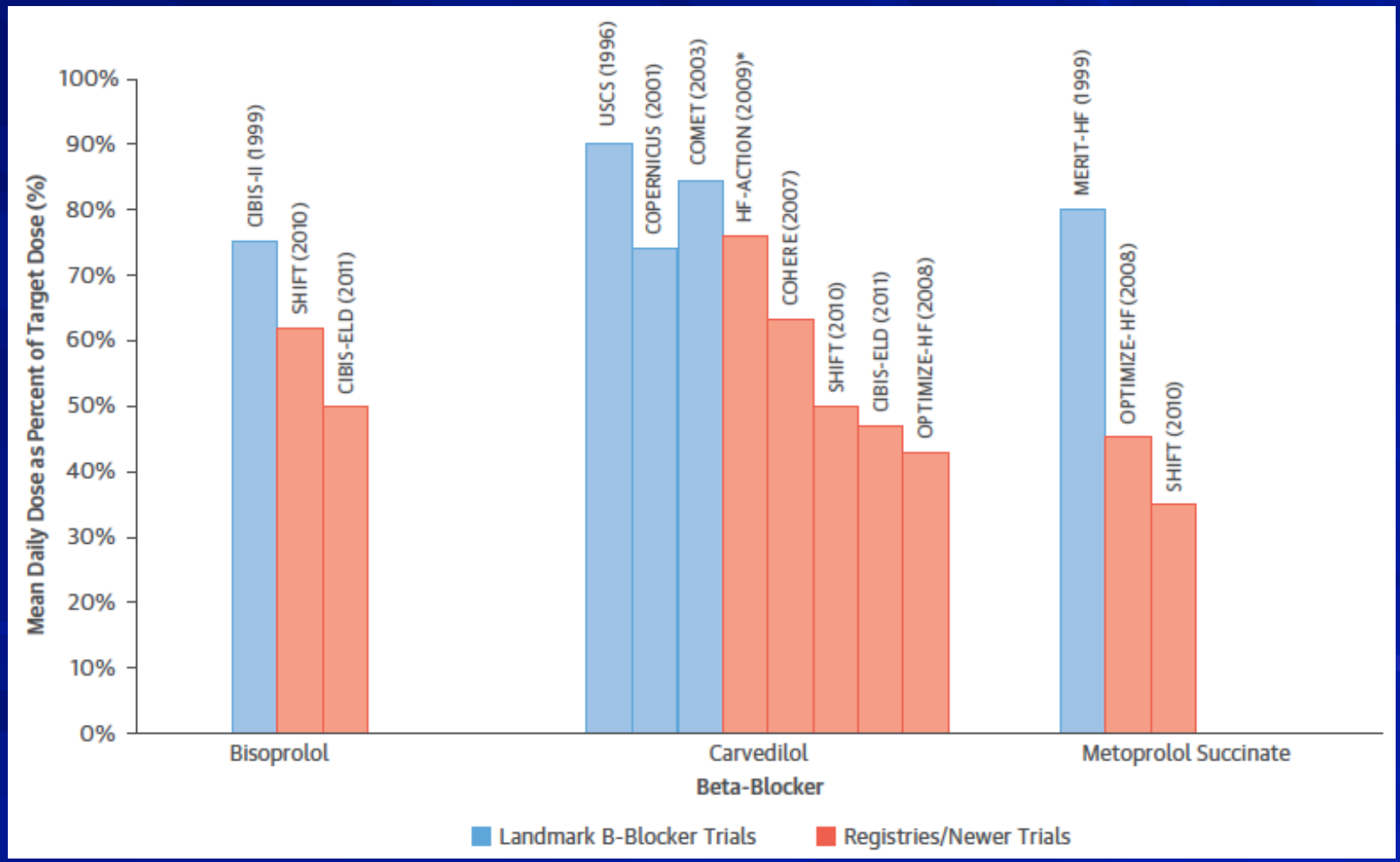
BETA BLOCKERS IN HEART FAILURE

TABLE 1 Characteristics of Major β-Blocker Trials in HF

	Study					
	USCS (N = 1,094)	**MERIT-HF (N = 3,991)**	**CIBIS-II (N = 2,647)**	**COPERNICUS (N = 2,289)**	**BEST (N = 2,708)**	**SENIORS (N = 2,128)**
β-blocker	Carvedilol	Metoprolol Succinate	Bisoprolol	Carvedilol	Bucindolol	Nebivolol
Mean age, yrs	58	64	61	64	60	76
Starting dose, mg	6.25 b.i.d.	12.5 q.d.	1.25 q.d.	3.125 b.i.d.	3.0 b.i.d.	1.25 q.d.
Target dose, mg	25-50 b.i.d.	200 q.d.	10 q.d.	25 b.i.d.	50-100 b.i.d.	10 q.d.
Mean daily dose achieved, mg	45.0	159.0	7.5	37.0	152.0	7.7
Baseline heart rate, beats/min*	84 ± 12	83 ± 10	80 ± 15	83 ± 13	82 ± 13	79 ± 14
Heart rate reduction, beats/min	12.6	−14.0	−9.8	NR	−9.4	−10.3
Baseline SBP, mm Hg*	116 ± 17	130 ± 17	129 ± 19	123 ± 19	117 ± 18	139 ± 20
Titration period, weeks	2-10	1-8	1-15	1-8	1-9	1-16
% Relative effect on all-cause mortality	↓ 65	↓ 34	↓ 34	↓ 35	↓ 10	↓ 12
p value	<0.001	<0.001	<0.001	<0.001	0.13	0.21

Bhatt AS et all. JACC 2017

BETA BLOCKERS IN HEART FAILURE



Bhatt AS et all. JACC 2017

Beta-blocker dose before, during, and after hospitalization for HF (OPTIMIZE-HF)

Doses changes in β-blocker therapy during hospitalization

β-Blocker Therapy	Dose Changes During Hospitalization		
	Reduced	Unchanged	Increased
Carvedilol (n = 1,162)	13.1%	70.3%	16.6%
Sustained-release metoprolol succinate (n = 422)	8.8%	76.5%	14.7%
Immediate-release metoprolol tartrate (n = 232)	10.6%	77.2%	12.2%
Atenolol (n = 91)	14.1%	74.6%	11.3%

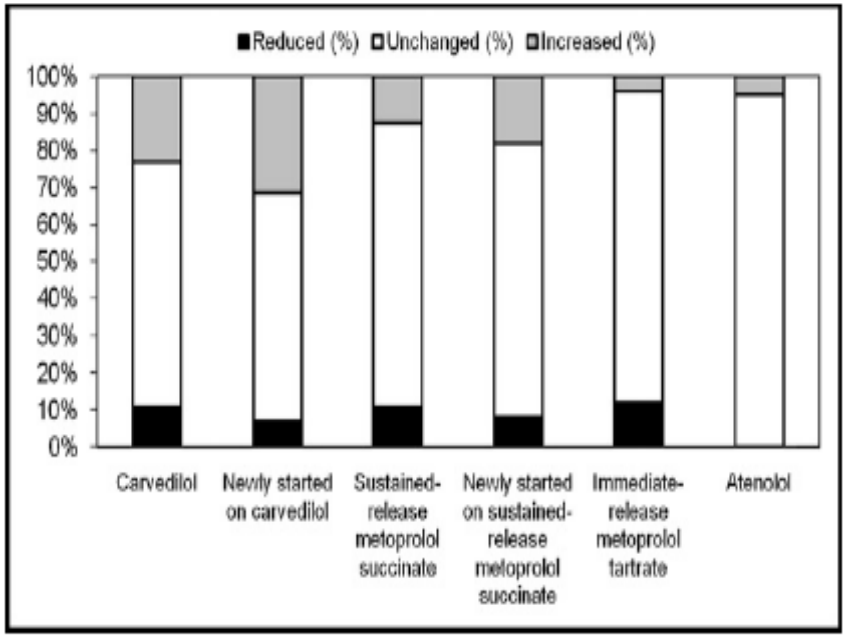


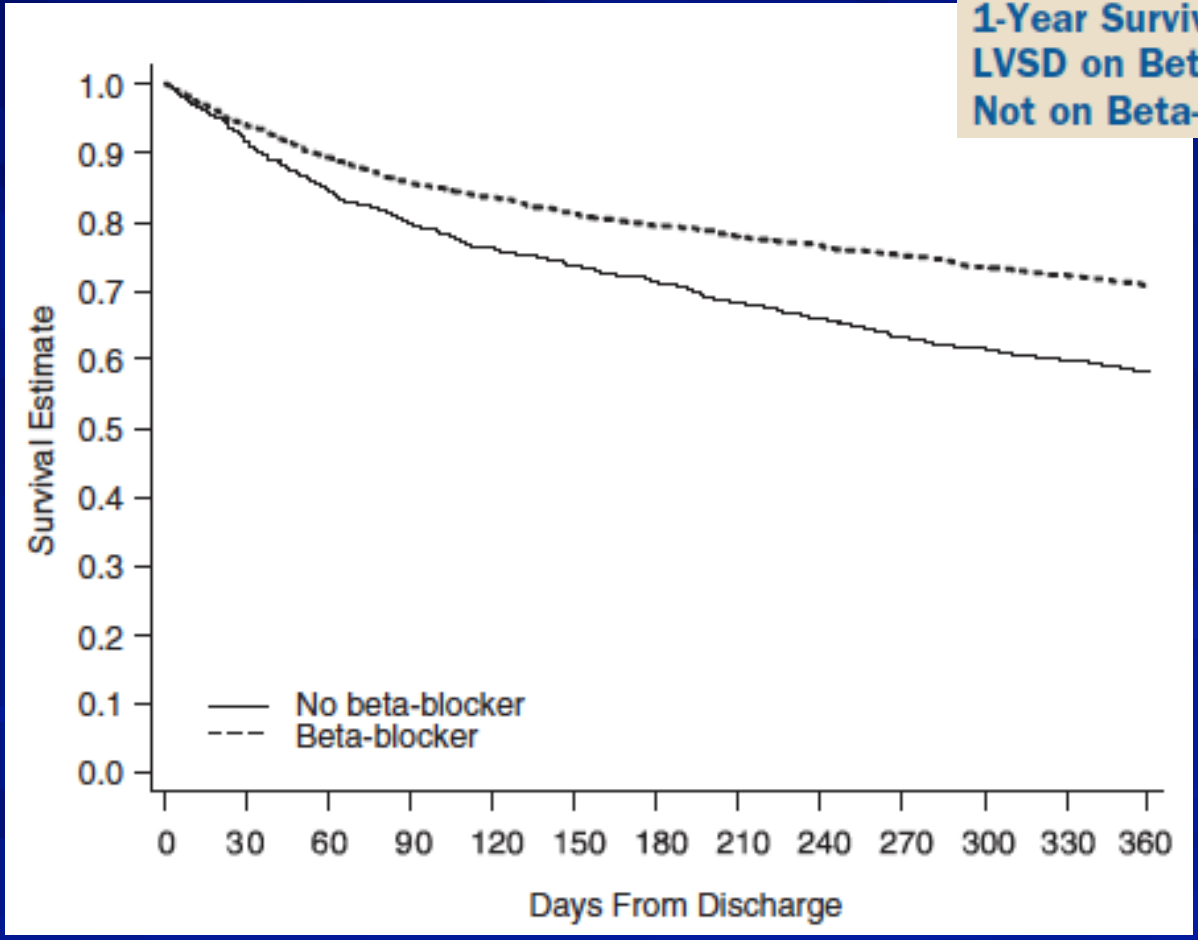
Figure 1. Beta-blocker titration during the first 60 to 90 days after hospital discharge. Distribution plot of the proportion of patients with β-blocker therapy dosing increased, decreased, or unchanged for specific β blockers during the first 60 to 90 days after hospital discharge.

Fonarow GC et al. AJC 2008

BETA BLOCKER UPON HF DISCHARGE

HFrEF

1-Year Survival for Eligible Patients With LVSD on Beta-Blocker Therapy Versus Patients Not on Beta-Blocker Therapy at Discharge



Hernandez AF et al. JACC 2009;53:184-92

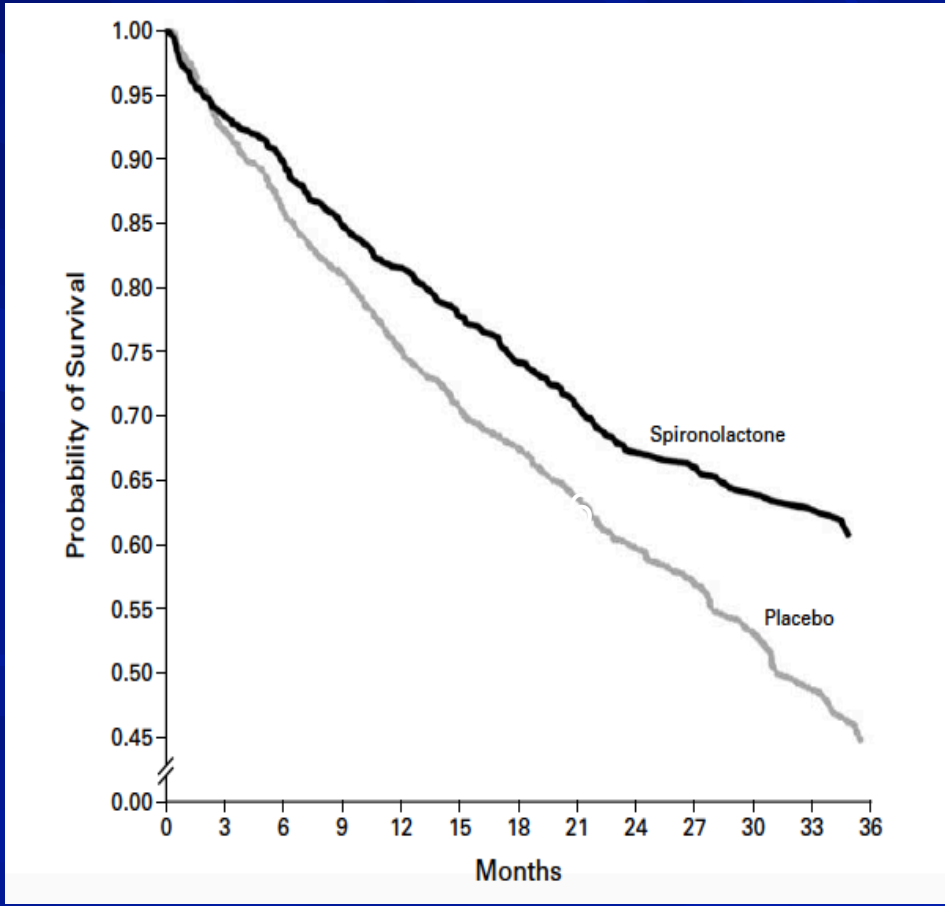
RALES: SPIRONOLACTONE IN HFrEF

EF <35% and NYHA class III–IV

Cr < 2.5 mg/dL

K+ < 5.0 mg/dL

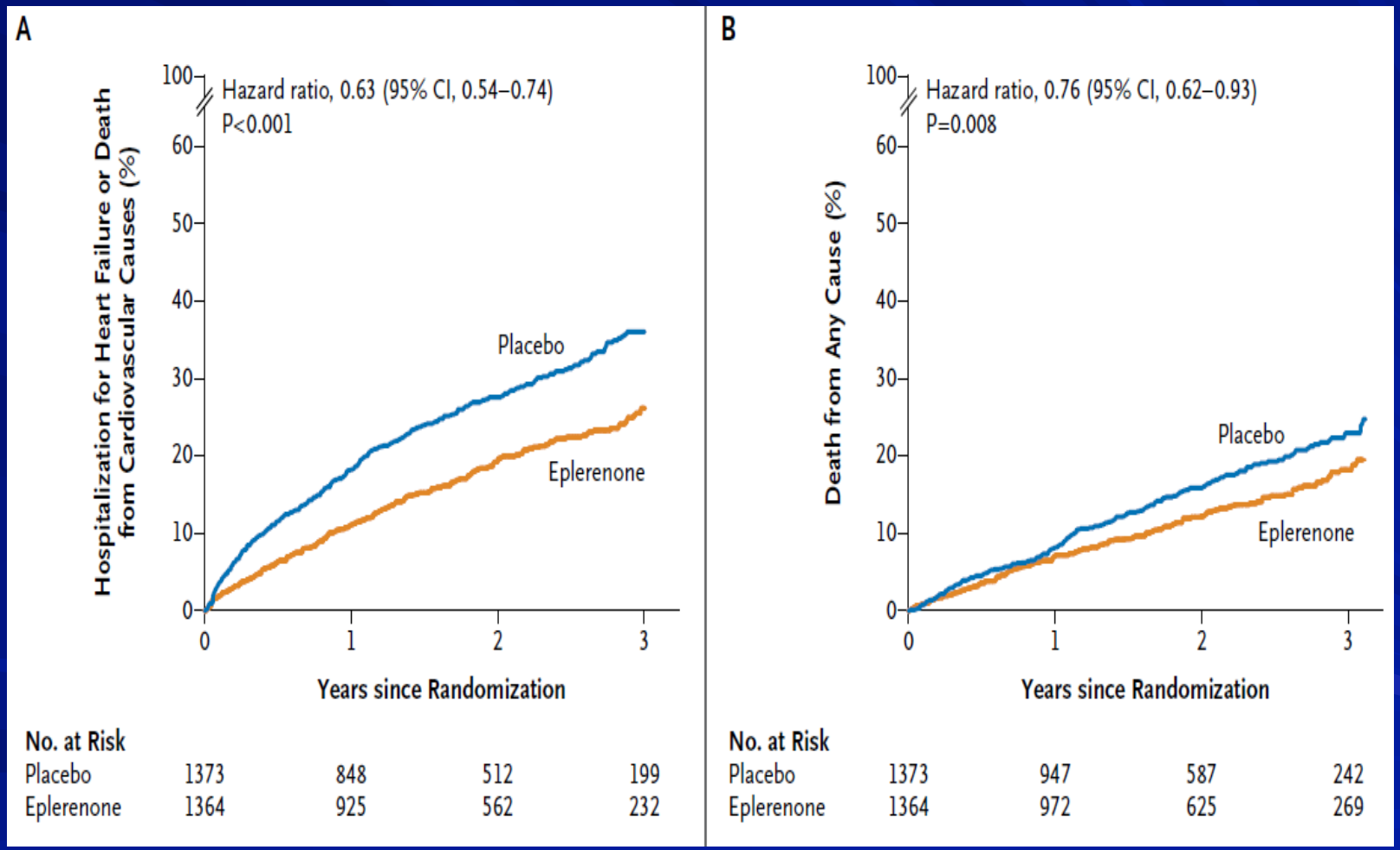
Stopped Early



P=<0.001

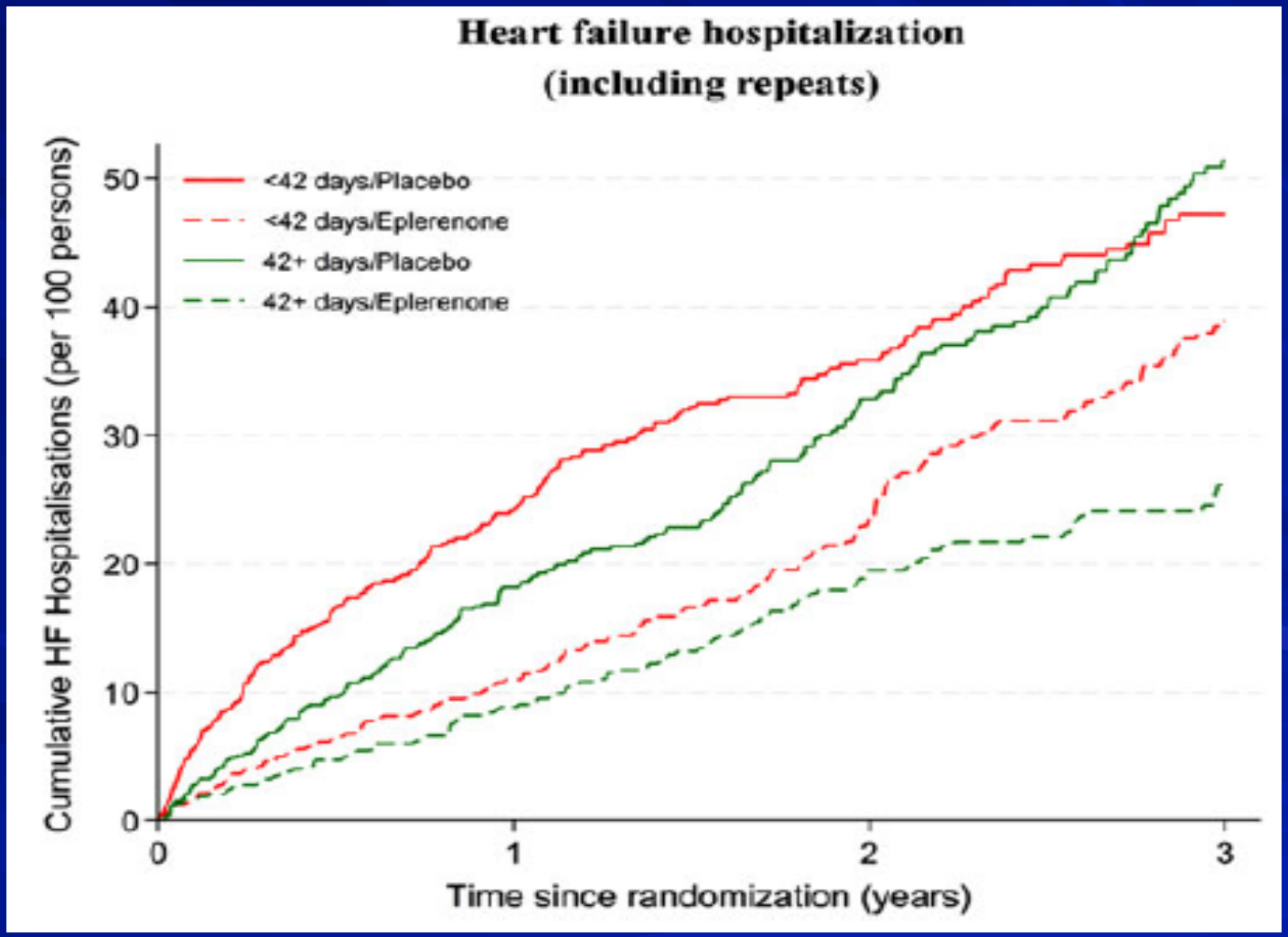
Pitt B. *N Engl J Med* 1999

EMPHASIS-HF: EPLERENONE in NYHA CLASS II HFrEF

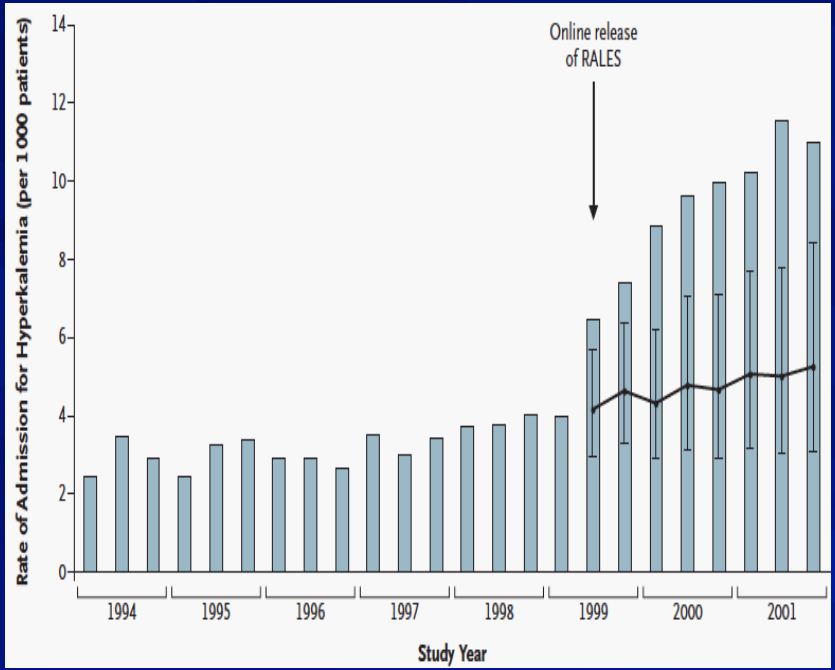


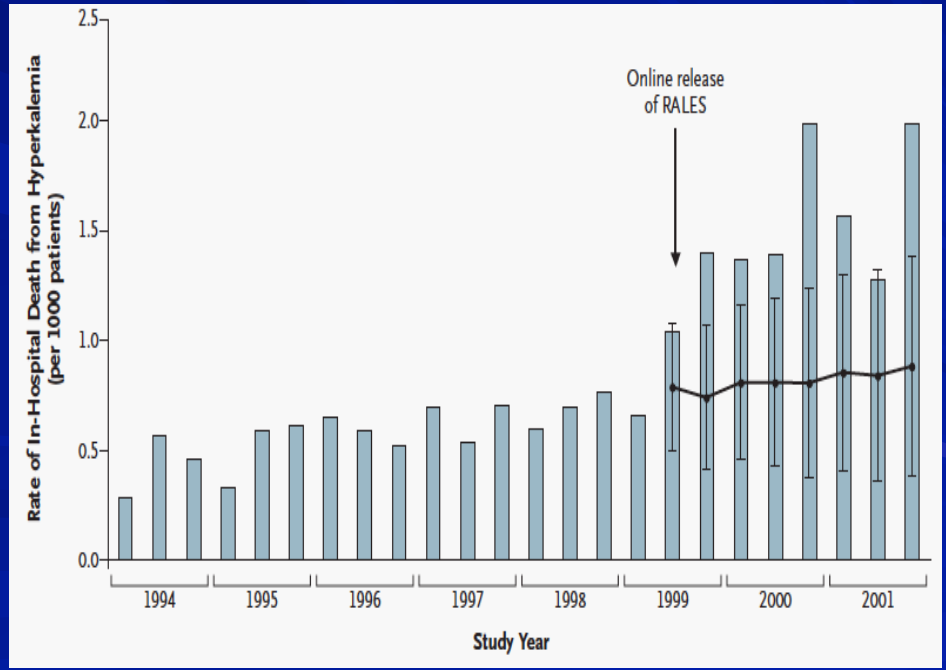
Zannad et al. NEJM 2011

Clinical benefits of eplerenone in patients with systolic heart failure and mild symptoms when initiated shortly after hospital discharge: analysis from the EMPHASIS-HF trial



HYPERKALEMIA AFTER RALES

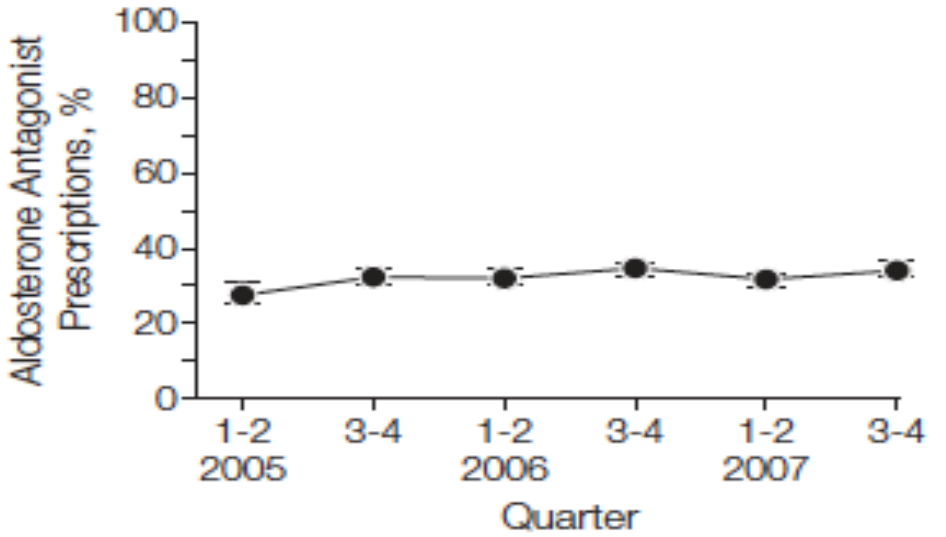




Juurlink DN et al. NEJM 2004

UNDER-UTILIZATION OF MRAs

Figure. Aldosterone Antagonist Use per American College of Cardiology/American Heart Association Heart Failure Management Guideline Criteria (N=12 565 Patients)



Albert NM et al. JAMA 2009

Improving Evidence-Based Care for Heart Failure in Outpatient Cardiology Practices

Primary Results of the Registry to Improve the Use of Evidence-Based Heart Failure Therapies in the Outpatient Setting (IMPROVE HF)

Methods and Results—Performance data were collected in a random sample of HF patients from 167 US outpatient cardiology practices at baseline, longitudinally after intervention at 12 and 24 months, and in single-point-in-time patient cohorts at 6 and 18 months. Participants included 34 810 patients with reduced left ventricular ejection fraction (≤35%) and chronic HF or previous myocardial infarction. To quantify guideline adherence, 7 quality measures were assessed. Interventions included clinical decision support tools, structured improvement strategies, and chart audits with feedback.

Fonarow GC et al. Circulation 2010

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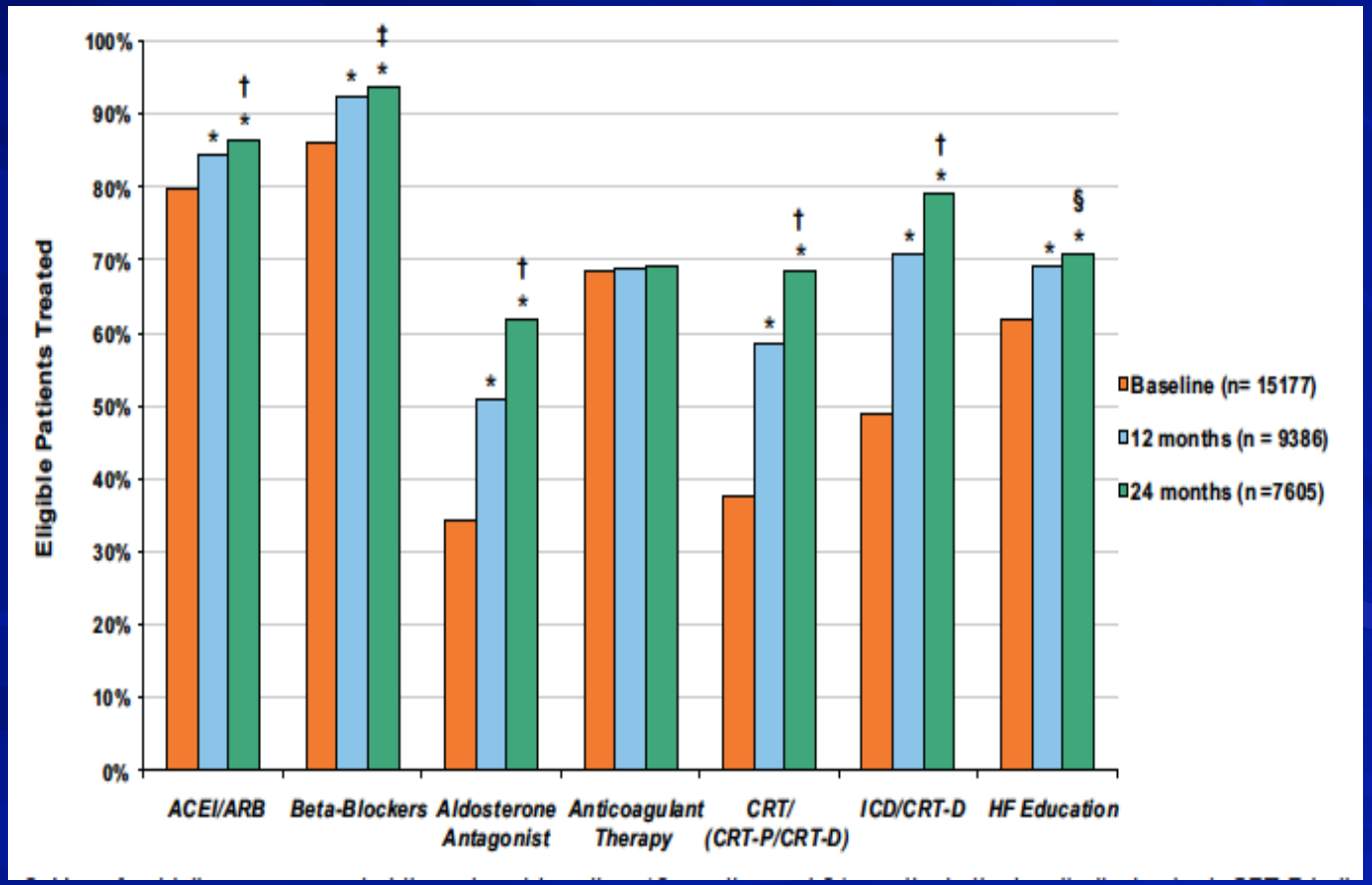
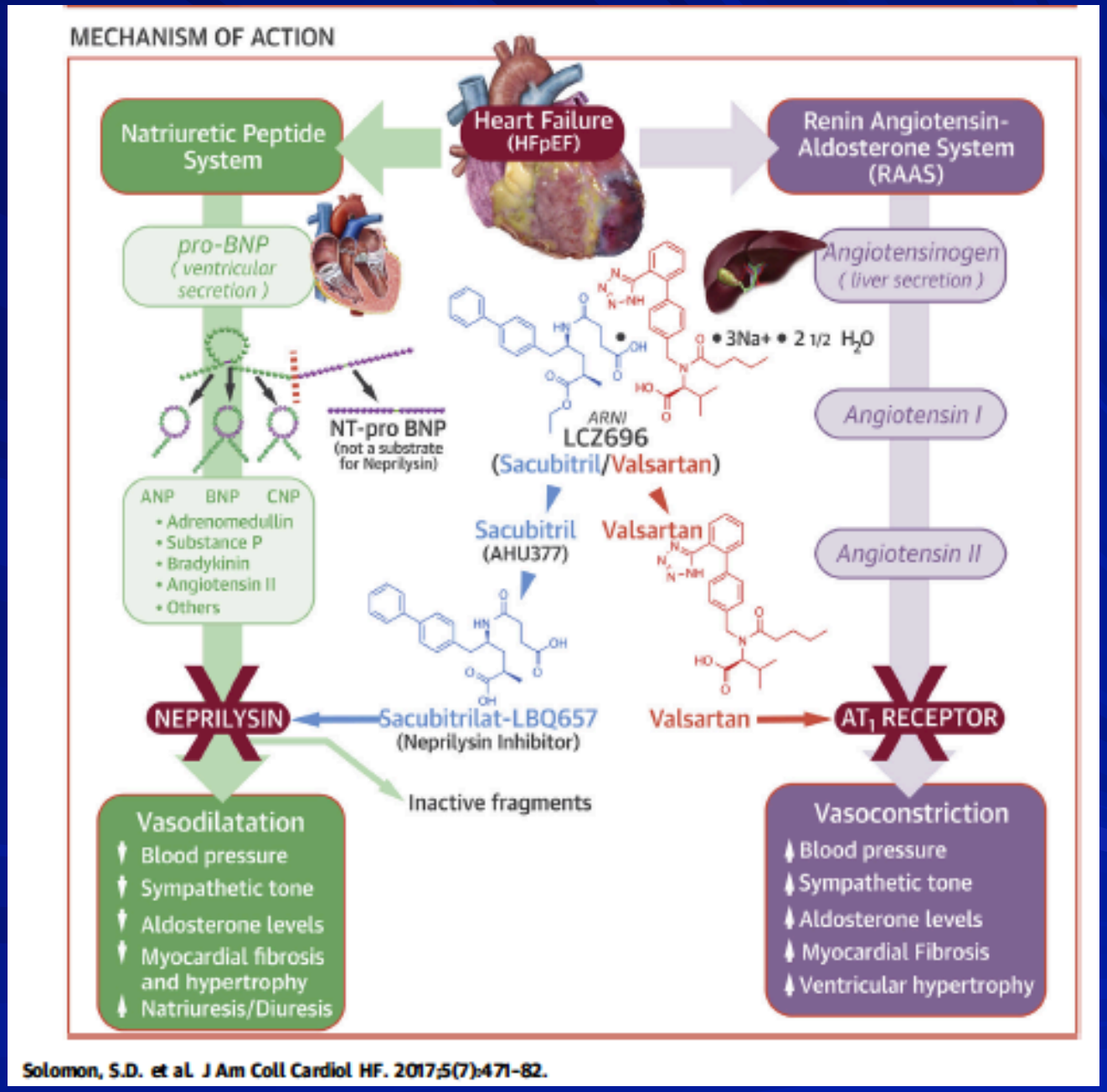


Fonarow GC et al. Circulation 2010

Under-utilization of aldosterone antagonists: PARADIGM-HF

Characteristic	LCZ696 (N=4187)	Enalapril (N=4212)
Treatments at randomization — no. (%)		
Diuretic	3363 (80.3)	3375 (80.1)
Digitalis	1223 (29.2)	1316 (31.2)
Beta-blocker	3899 (93.1)	3912 (92.9)
Mineralocorticoid antagonist	2271 (54.2)	2400 (57.0)
Implantable cardioverter–defibrillator	623 (14.9)	620 (14.7)
Cardiac resynchronization therapy	292 (7.0)	282 (6.7)

McMurray JJV et al. NEJM 2014

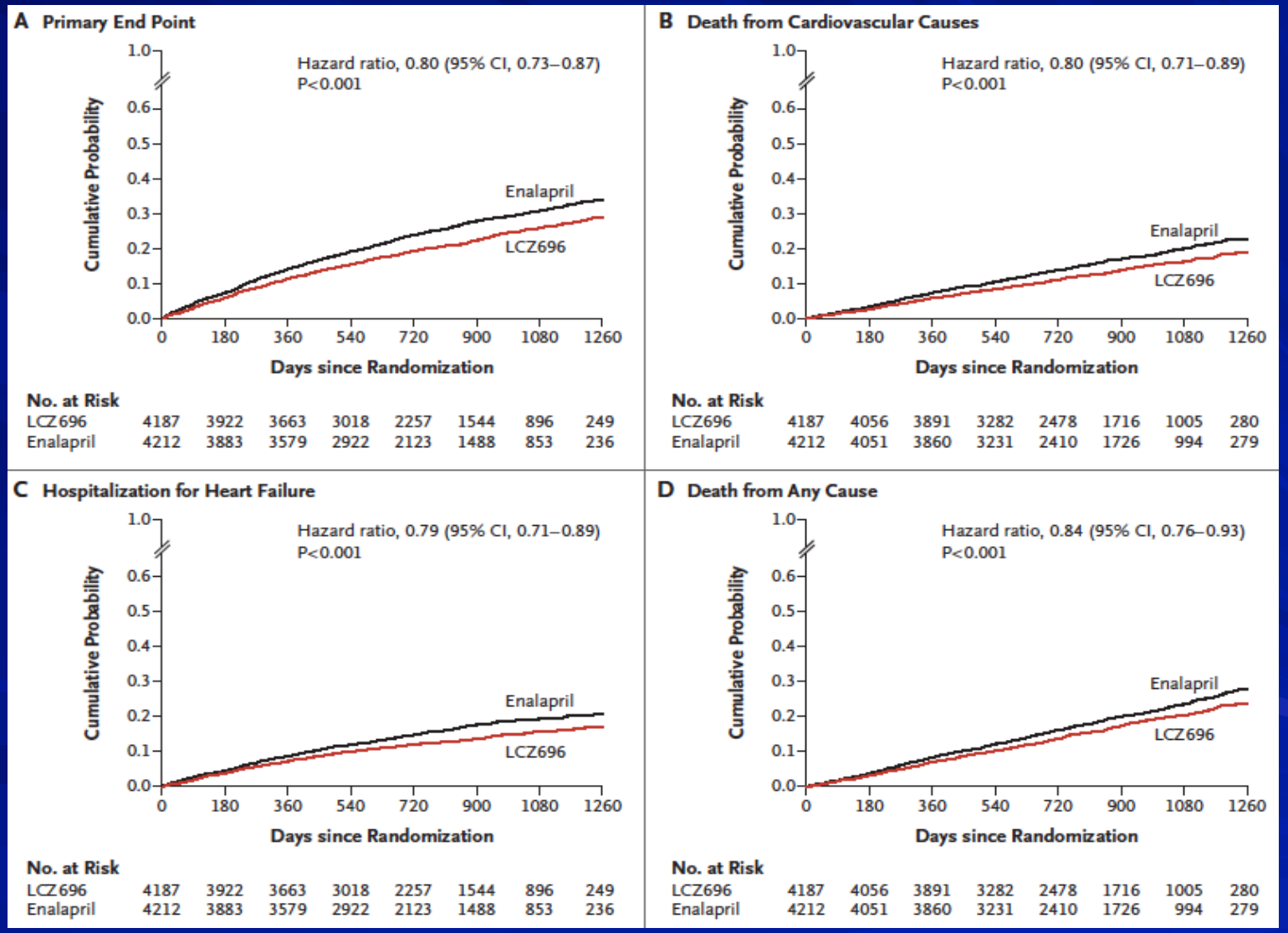


Solomon, S.D. et al. J Am Coll Cardiol HF. 2017;5(7):471–82.

PARADIGM-HF

- LVEF < 40%
- NYHA class II-IV
- Elevated BNP and/or HF hospitalization within 12 months
- Stable dose of beta-blocker and an ACEi/ARB equivalent to at least 10 mg/day of enalapril
- Exclusion:
  - SBP < 100 mm Hg
  - GFR < 30 ml/min/1.73 m2 of BSA
  - K > 5.2 mmol/L
  - Hx of angioedema or unacceptable side effects during receipt of ACEi/ARB

PARADIGM-HF



McMurray JJV et al. NEJM 2014

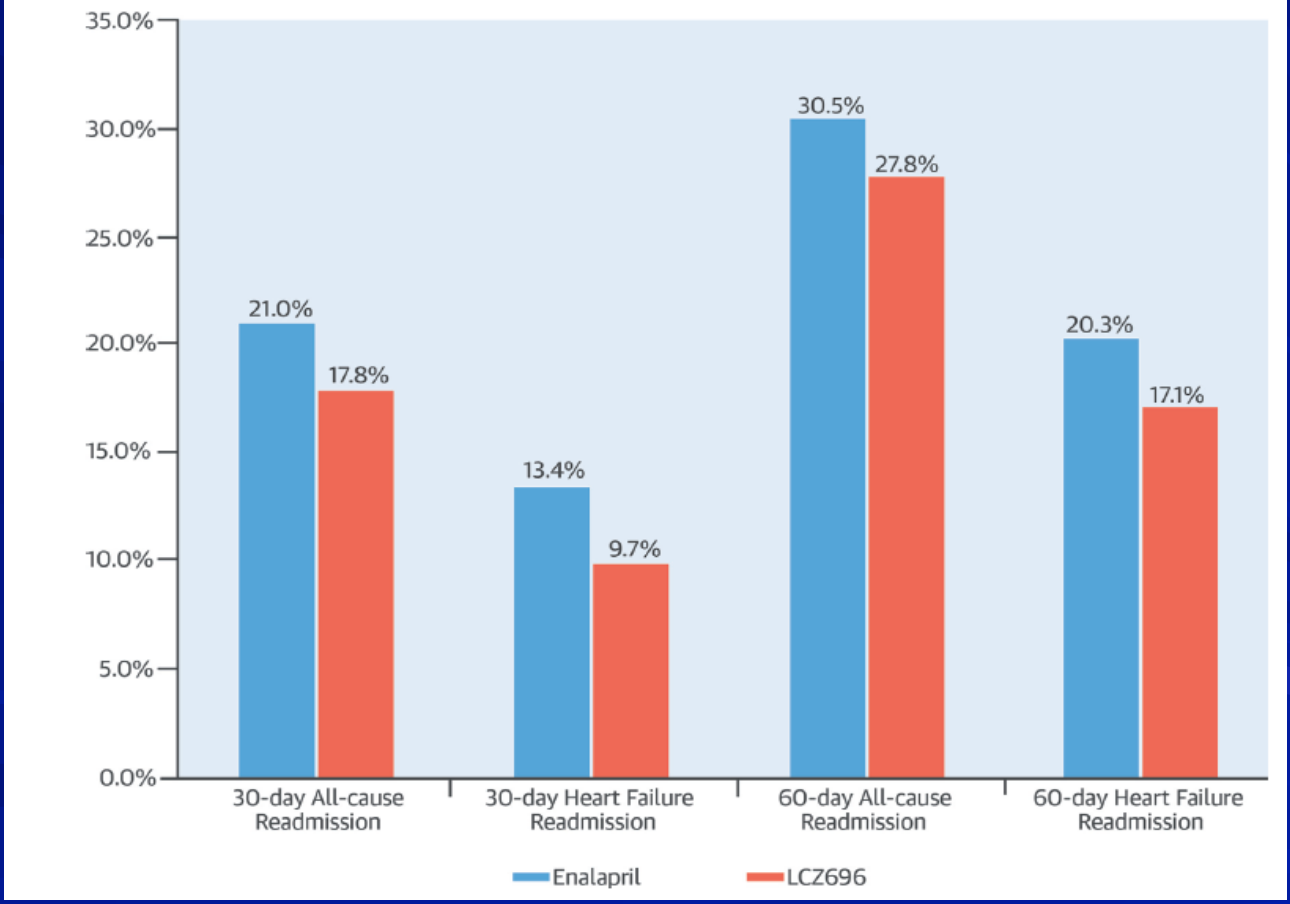
PARADIGM-HF

Table 3. Adverse Events during Randomized Treatment.*

Event	LCZ696 (N=4187)	Enalapril (N=4212)	P Value
	no. (%)		
Hypotension			
Symptomatic	588 (14.0)	388 (9.2)	<0.001
Symptomatic with systolic blood pressure <90 mm Hg	112 (2.7)	59 (1.4)	<0.001
Elevated serum creatinine			
≥2.5 mg/dl	139 (3.3)	188 (4.5)	0.007
≥3.0 mg/dl	63 (1.5)	83 (2.0)	0.10
Elevated serum potassium			
>5.5 mmol/liter	674 (16.1)	727 (17.3)	0.15
>6.0 mmol/liter	181 (4.3)	236 (5.6)	0.007
Cough	474 (11.3)	601 (14.3)	<0.001
Angioedema†			
No treatment or use of antihistamines only	10 (0.2)	5 (0.1)	0.19
Use of catecholamines or glucocorticoids without hospitalization	6 (0.1)	4 (0.1)	0.52
Hospitalization without airway compromise	3 (0.1)	1 (<0.1)	0.31
Airway compromise	0	0	—

McMurray JJV et al. NEJM 2014

PARADIGM-HF: 30 DAY READMISSIONS

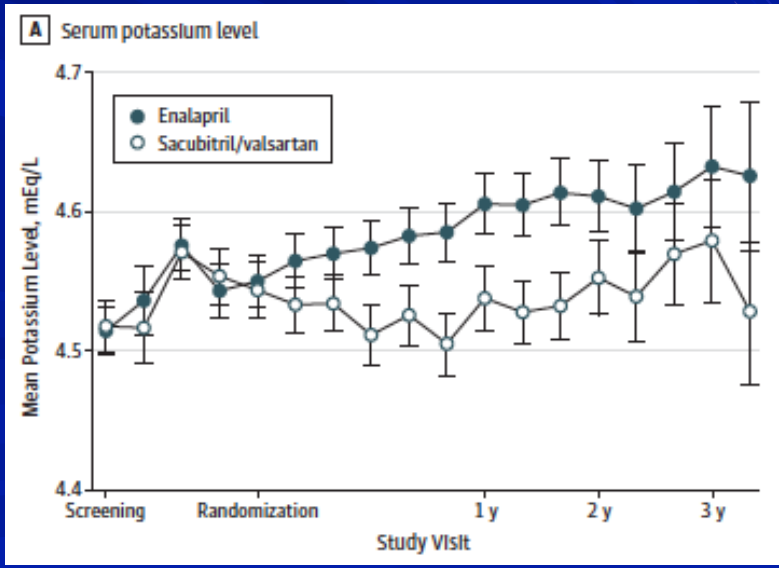


Desai AS et al. JACC 2016

PARADIGM-HF: RISK OF HYPERKALEMIA

Table 2. Incidence of Hyperkalemia During Follow-up in the PARADIGM-HF Trial According to MRA Use at Baseline and Treatment Assignment

MRA Use	Patients Receiving ENL, No. (%)	Incidence[a]	Patients Receiving LCZ, No. (%)	Incidence[a]	HR (ENL vs LCZ) (95% CI)	*P* Value	Adjusted HR (ENL vs LCZ) (95% CI)	*P* Value
No MRA at baseline								
Hyperkalemia[b]	278 (15.3)	7.4	288 (15.0)	7.2	1.02 (0.87-1.20)	.81	1.08 (0.91-1.28)	.39
Severe Hyperkalemia[c]	90 (5.0)	2.2	78 (4.1)	1.8	1.23 (0.91-1.67)	.17	1.30 (0.96-1.78)	.09
MRA at baseline								
Hyperkalemia[b]	448 (18.7)	10.6	386 (17.0)	9.4	1.12 (0.98-1.28)	.11	1.12 (0.97-1.29)	.11
Severe Hyperkalemia[c]	146 (6.1)	3.1	103 (4.5)	2.2	1.37 (1.06-1.76)	.02	1.41 (1.09-1.83)	<.01



Desai AS et al. JAMA Cardiol 2017

2016 FOCUSED UPDATE FOR HF

I	ACE: A ARB: A ARNI: B-R	**The clinical strategy of inhibition of the renin-angiotensin system with ACE inhibitors *(Level of Evidence: A)*, OR ARBs *(Level of Evidence: A)*, OR ARNI *(Level of Evidence: B-R)* in conjunction with evidence-based beta blockers, and aldosterone antagonists in selected patients, is recommended for patients with chronic HF*r*EF to reduce morbidity and mortality.**

I	ARNI: B-R	**In patients with chronic symptomatic HF*r*EF NYHA class II or III who tolerate an ACE inhibitor or ARB, replacement by an ARNI is recommended to further reduce morbidity and mortality.**

Yancy CW et al. JACC 2016

2016 FOCUSED UPDATE FOR HF

III: Harm	B-R

ARNI should not be administered concomitantly with ACE inhibitors or within 36 hours of the last dose of an ACE inhibitor (31,32).

III: Harm	C-EO

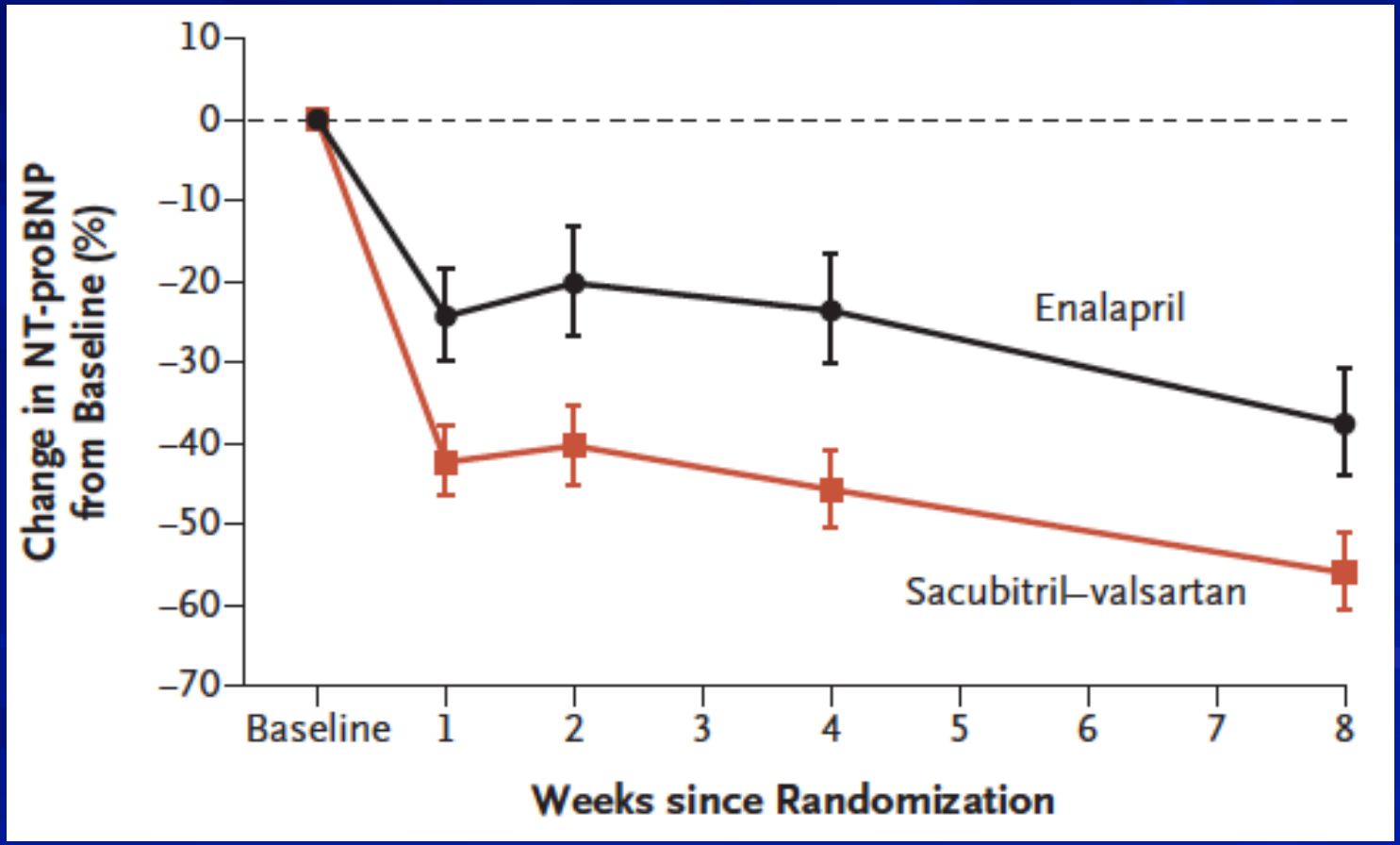
ARNI should not be administered to patients with a history of angioedema.

Yancy CW et al. JACC 2016

ARNI IN ACUTE DECOMPENSATED HF

- PIONEER-HF enrolled HFrEF patients who were hospitalized for ADHF
- After hemodynamic stabilization, patients were randomly assigned to receive sacubitril-valsartan or enalapril
- Primary outcome was the change in NT-proBNP from baseline through weeks 4 and 8

ARNI IN ACUTE DECOMPENSATED HF



Velazquez EJ et al. NEJM 2019;380:539-548

ARNI IN ACUTE DECOMPENSATED HF CAVEATS

- Systolic BP > 100 mm Hg during preceding 6 hours prior to initial dose
- No increase in dose of IV diuretics
- No use of IV inotropic support during the preceding 24 hours
- Make sure patient has insurance coverage

ARNI - KEY POINTS

- Contraindicated if patient has history of angioedema
- Largest side effect is hypotension
- No benefit in HFpEF
- No washout period is needed if switching from ARB

SGLT2 INHIBITORS

- Inhibit sodium-glucose co-transporters in the kidney
- Prevents the kidneys' uptake of glucose from the glomerular filtrate and promotes the excretion of glucose in the urine
- Also leads to reduced sodium reabsorption in proximal tubule and increased sodium excretion leading to a diuretic effect
- Drop in SBP and DBP
- Studies in diabetic patients demonstrated a reduction in risk of hospitalization for HF (mainly in patients who did not have HF at baseline)

Dapagliflozin in Patients with Heart Failure and Reduced Ejection Fraction

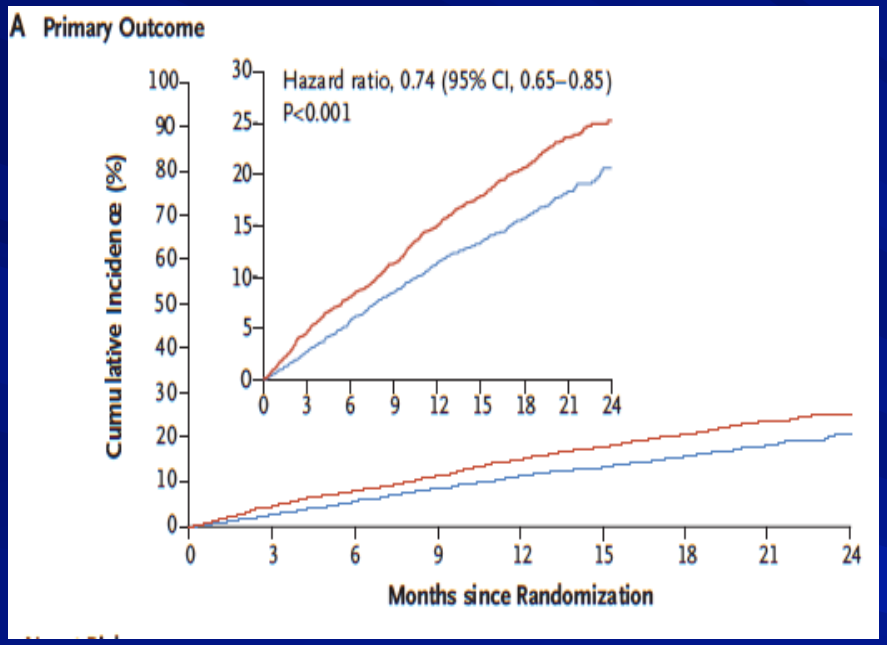
- DAPA-HF is a prospective placebo-controlled study to evaluate efficacy of dapagliflozin in HF patients with reduced EF, regardless of presence or absence of DM
- Primary outcome was a composite of worsening HF or death from CV cause

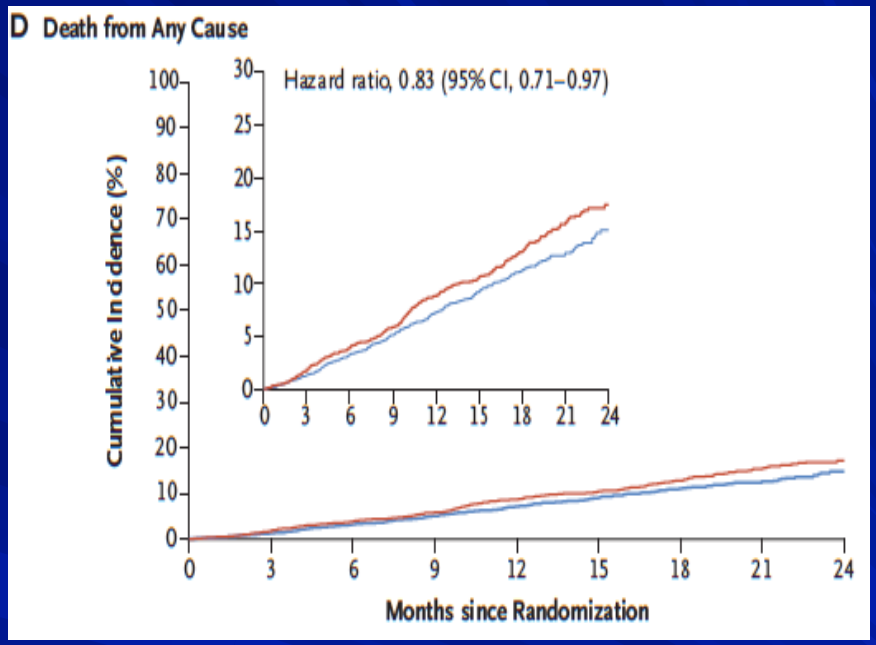
DAPA-HF

Characteristic	Dapagliflozin (N=2373)	Placebo (N=2371)
Age — yr	66.2±11.0	66.5±10.8
Female sex — no. (%)	564 (23.8)	545 (23.0)
Body-mass index†	28.2±6.0	28.1±5.9
Race — no. (%)‡		
White	1662 (70.0)	1671 (70.5)
Black	122 (5.1)	104 (4.4)
Asian	552 (23.3)	564 (23.8)
Other	37 (1.6)	32 (1.3)
Region — no. (%)		
North America	335 (14.1)	342 (14.4)
South America	401 (16.9)	416 (17.5)
Europe	1094 (46.1)	1060 (44.7)
Asia–Pacific	543 (22.9)	553 (23.3)
NYHA functional classification — no. (%)		
II	1606 (67.7)	1597 (67.4)
III	747 (31.5)	751 (31.7)
IV	20 (0.8)	23 (1.0)
Heart rate — beats/min	71.5±11.6	71.5±11.8
Systolic blood pressure — mm Hg	122.0±16.3	121.6±16.3
Left ventricular ejection fraction — %	31.2±6.7	30.9±6.9
Median NT-proBNP (IQR) — pg/ml	1428 (857–2655)	1446 (857–2641)
Principal cause of heart failure — no. (%)		
Ischemic	1316 (55.5)	1358 (57.3)
Nonischemic	857 (36.1)	830 (35.0)
Unknown	200 (8.4)	183 (7.7)
Medical history — no. (%)		
Hospitalization for heart failure	1124 (47.4)	1127 (47.5)
Atrial fibrillation	916 (38.6)	902 (38.0)
Diabetes mellitus§	993 (41.8)	990 (41.8)
Estimated GFR		
Mean — ml/min/1.73 m^2	66.0±19.6	65.5±19.3
Rate of <60 ml/min/1.73 m^2 — no./total no. (%)	962/2372 (40.6)	964/2371 (40.7)
Device therapy — no. (%)		
Implantable cardioverter–defibrillator¶	622 (26.2)	620 (26.1)
Cardiac resynchronization therapy‖	190 (8.0)	164 (6.9)

McMurray JJV et al. NEJM 2019;381:1995-2008

DAPA-HF





- Findings in DM patients were similar to those in patients without DM
- Frequency of adverse events related to volume depletion, renal dysfunction, and hypoglycemia did not differ between treatment groups

McMurray JJV et al. NEJM 2019;381:1995-2008

QUADRUPLE THERAPY FOR ALL HFrEF PATIENTS?

- Beta blocker
- ACEi / ARB / ARNI
- MRA
- SGLT-2 Inhibitor

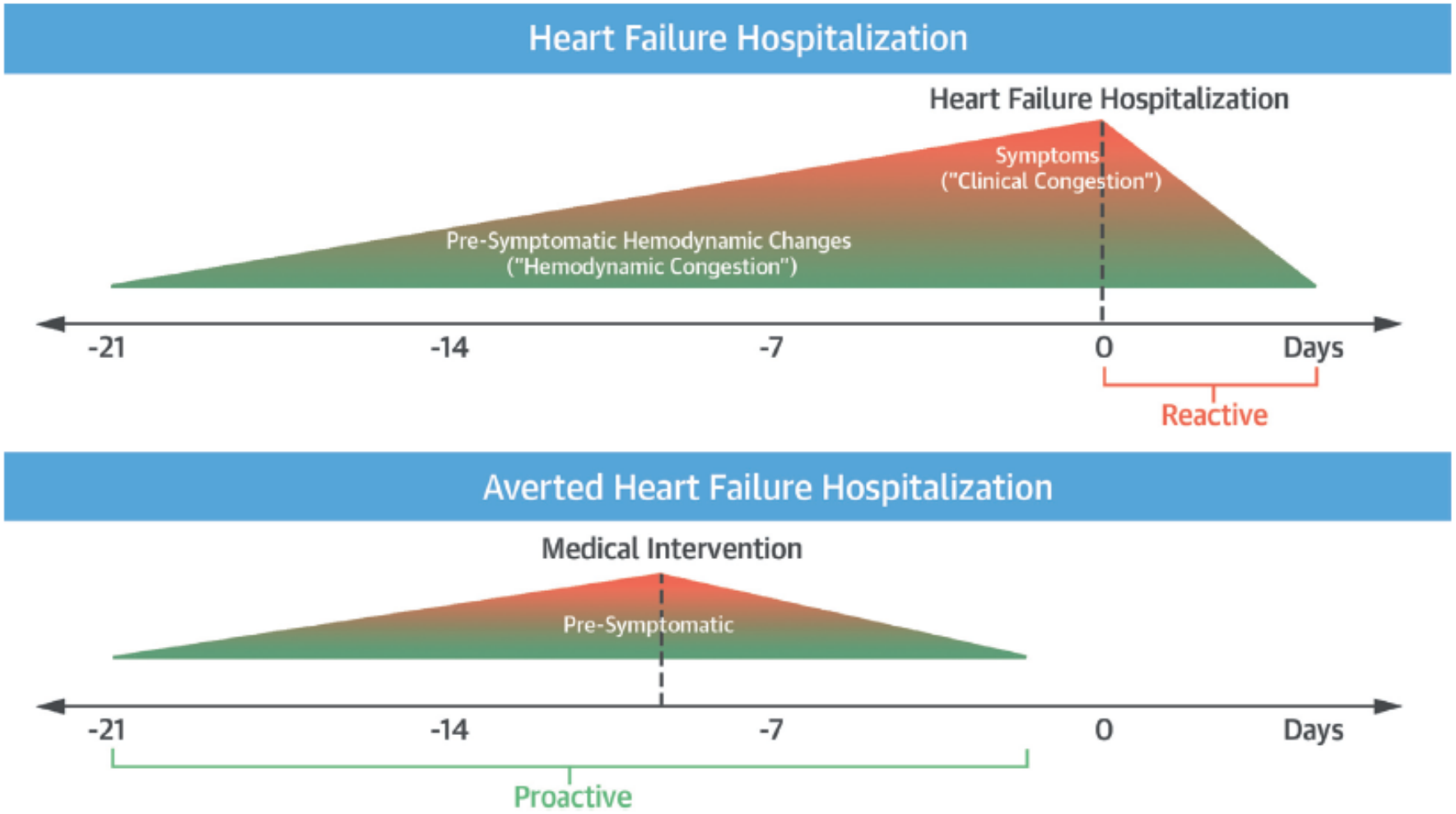
HOW TO PREVENT ADHF HOSPITALIZATION

- Challenge of closely monitoring outpatients
- Echocardiogram, CXR, and physical exam findings poorly correspond to a patient's volume status
- Patient's complaints may be nonspecific
- Can we measure and track a patient's filling pressures on a daily basis so that intervention can be performed before hospitalization?

IMPLANTABLE HEMODYNAMIC MONITORING

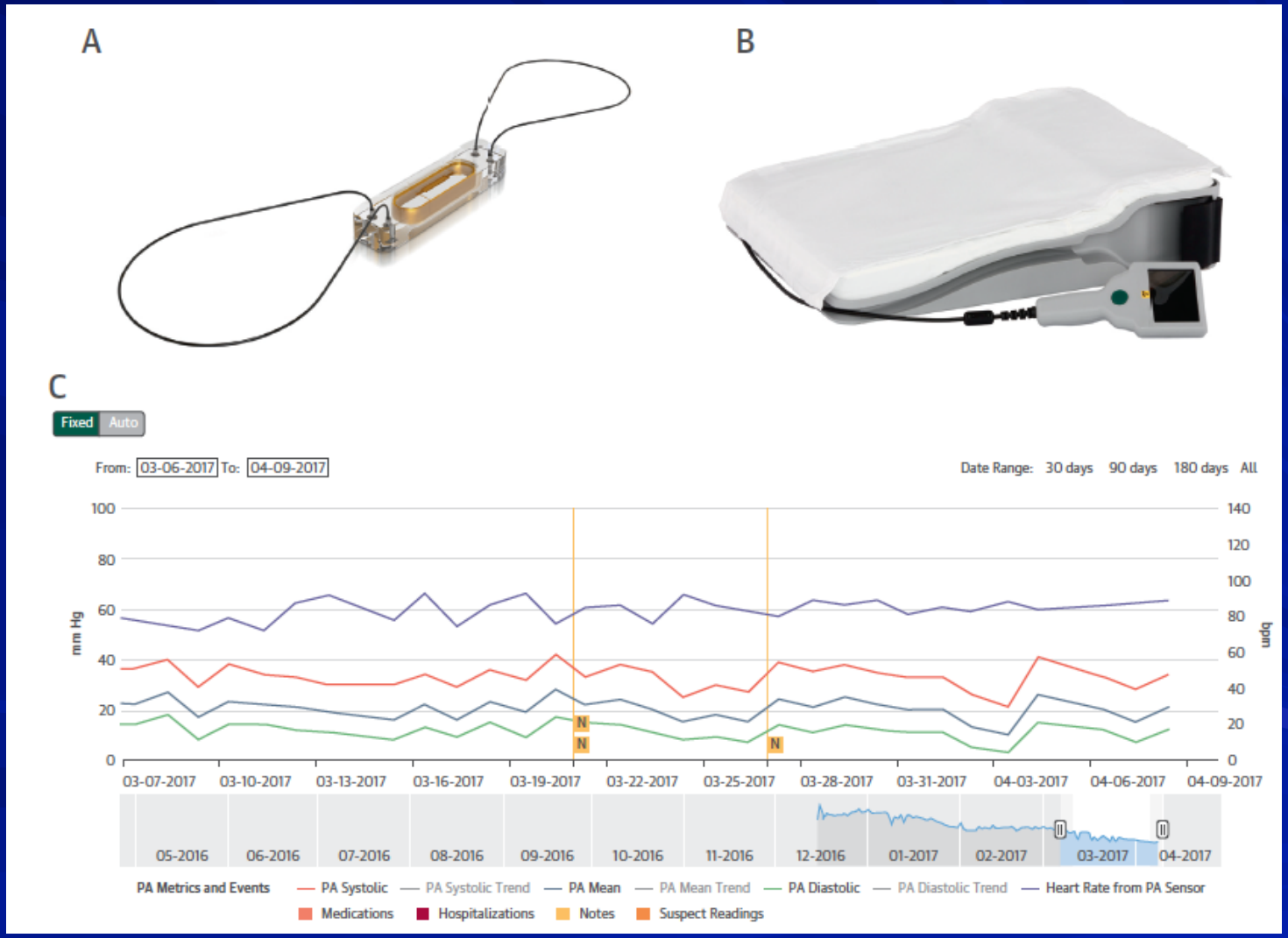
- Can implantation of a hemodynamic monitor to continuously measure PA pressures improve outcomes in HF?
- The rise of PA pressures due to CHF can occur several days to weeks prior to the development of symptoms
- Acting on these changes can help prevent hospital admission / readmission

CENTRAL ILLUSTRATION **The Concept of Pressure-Guided Heart Failure Therapy**



Abraham, W.T. et al. J Am Coll Cardiol. 2017;70(3):389–98.

CARDIOMEMS HF SYSTEM

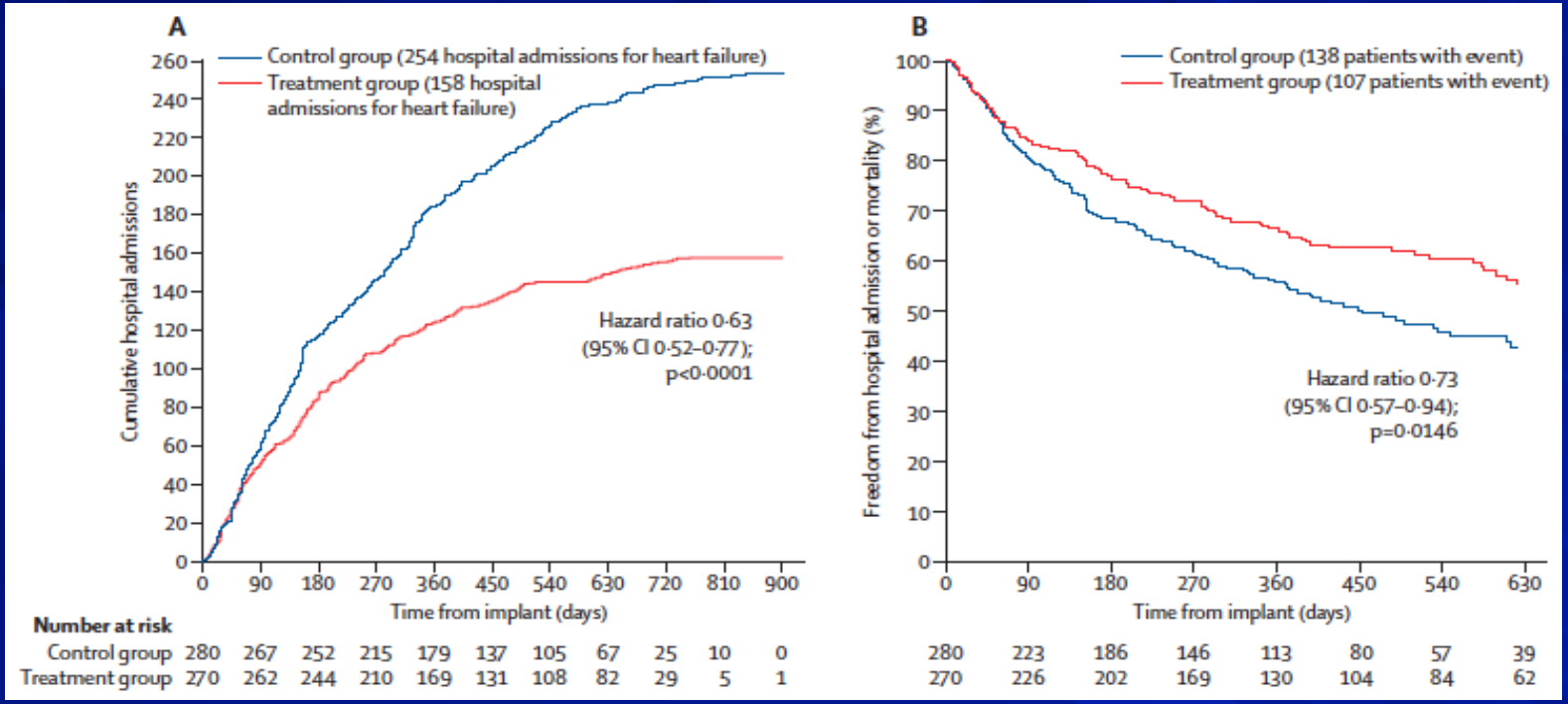


Abraham WT and Perl L. JACC 2017

CHAMPION

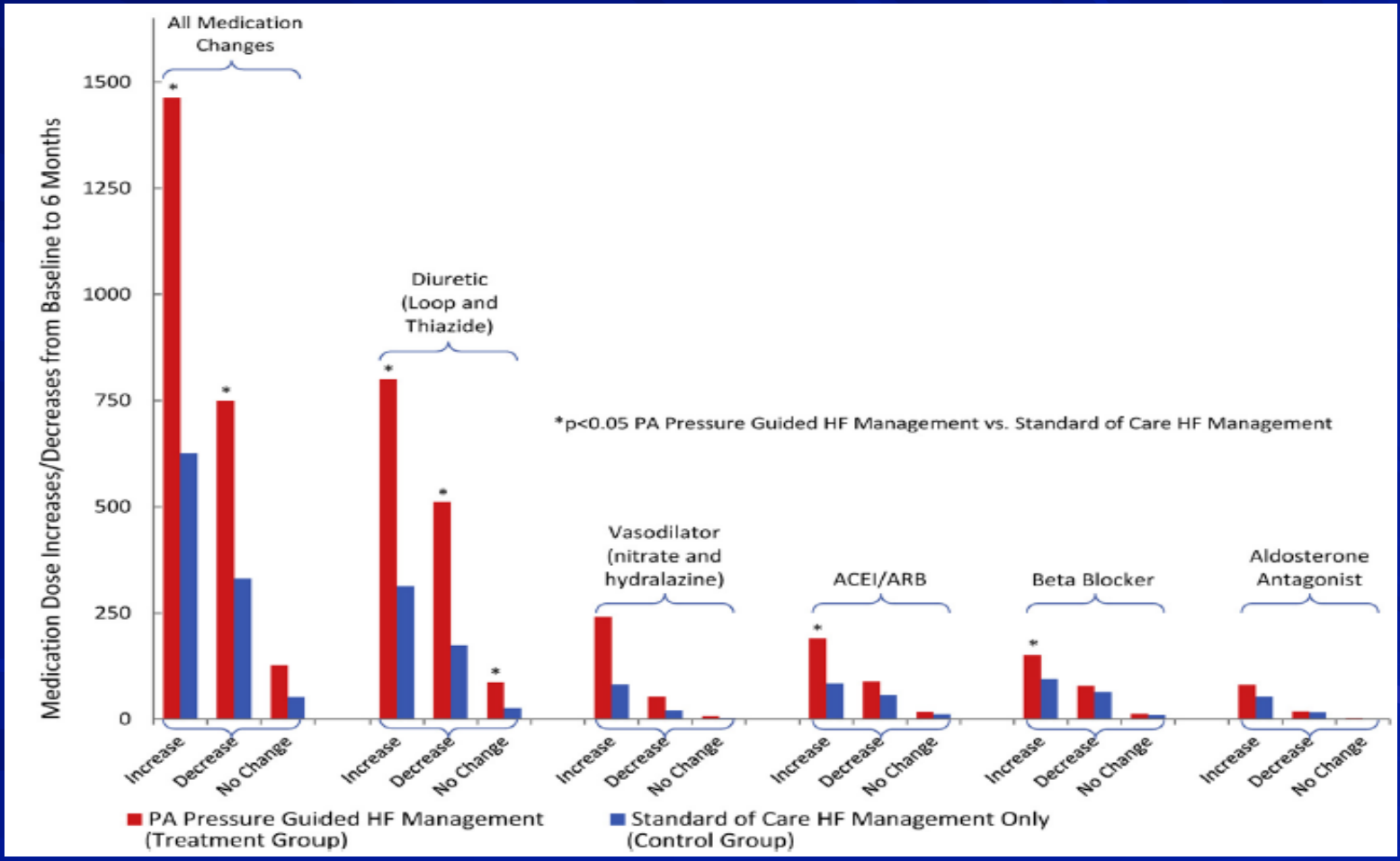
- Inclusion criteria:
  - Adults w/ NYHA class III HF for > 3 months
  - CHF hospitalization within 12 months
- Exclusion criteria:
  - Advanced renal failure
  - No LVEF criteria
  - Recent CRT
- Physicians were instructed to lower PA pressures when elevated, using neurohormonal, diuretic, or vasodilator drugs
- Review of pressure data occurred at least once per week and more frequently if changes occurred during treatment

CHAMPION



- No device related fatalities were noted
- 39% reduction in HF related hospitalization occurred in treatment group
- Clinicians were not blinded

CHAMPION TRIAL: EFFECT ON OMT



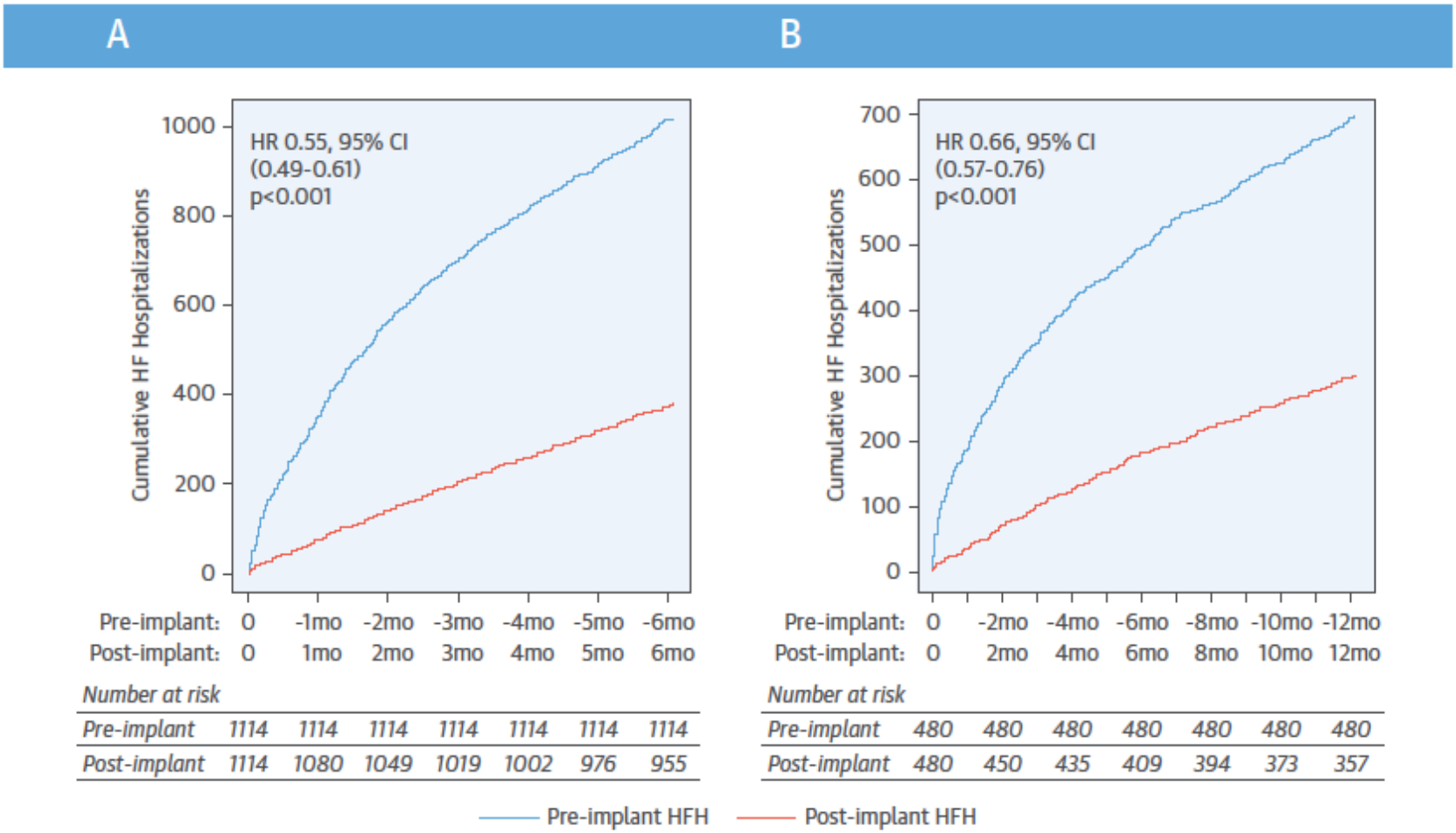
Costanzo MR et al. JACC HF 2016

Ambulatory Hemodynamic Monitoring Reduces Heart Failure Hospitalizations in "Real-World" Clinical Practice

TABLE 1 Patient Characteristics (on the Basis of Medicare Claims Data) at the Time of PAP Sensor Implantation for Cohorts With 6- and 12-Month Data Available

	6-Month Cohort (n = 1,114)	12-Month Cohort (n = 480)
Age, yrs	71.3 ± 10.8	71.4 ± 11.4
Age ≥75 yrs	460 (41.3)	211 (44.0)
Female	403 (36.2)	180 (37.5)
Race		
White	902 (81.0)	396 (82.5)
Black	161 (14.5)	69 (14.4)
Other	51 (4.6)	15 (3.1)
Comorbidities*		
Diabetes	727 (65.3)	311 (64.8)
Hypertension	1,089 (97.8)	471 (98.1)
COPD	861 (77.3)	384 (80.0)

CENTRAL ILLUSTRATION **Cumulative HFHs During the Period Before and After Pulmonary Artery Pressure Sensor Implantation**



Number at risk

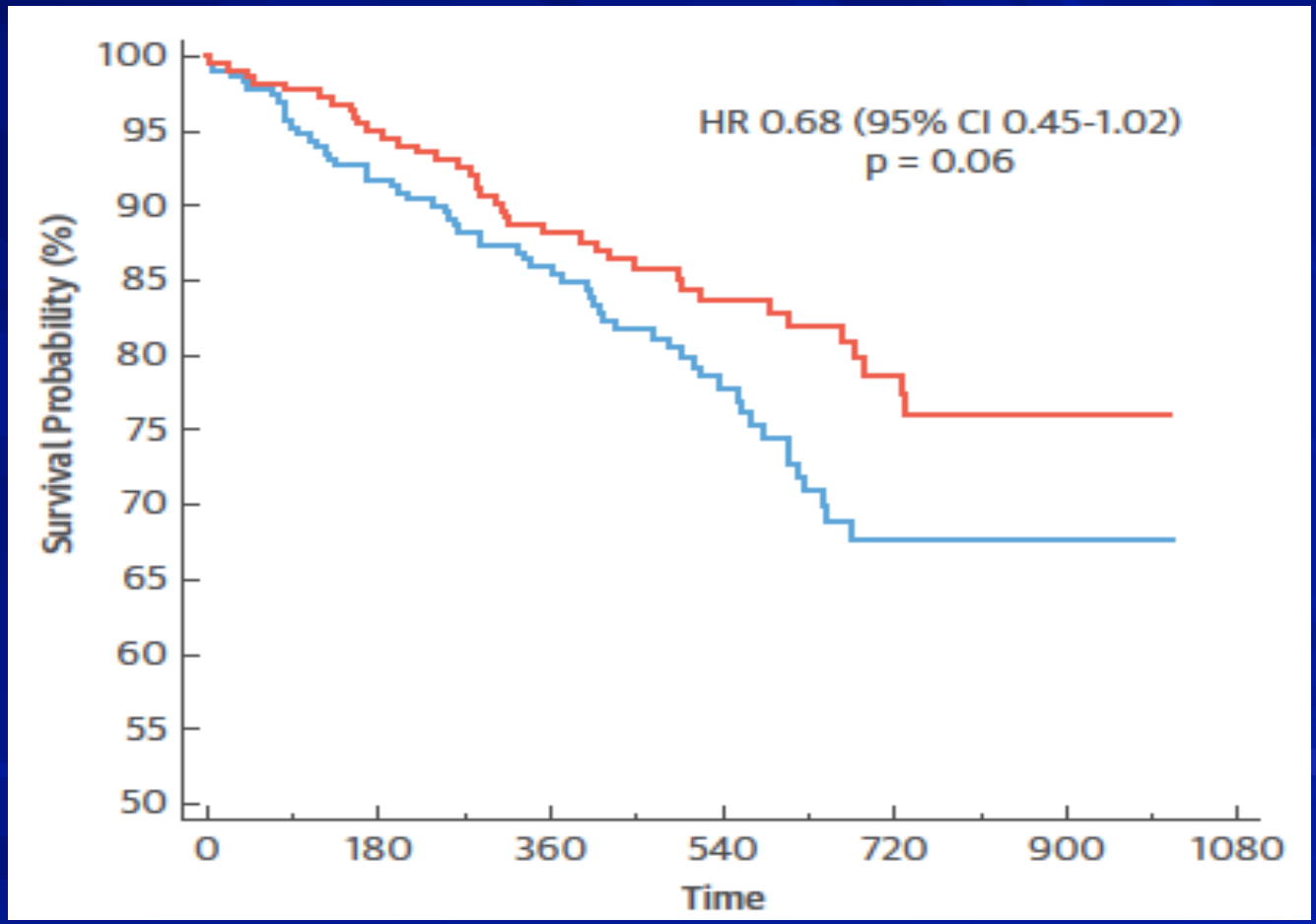
Pre-implant	*1114*	*1114*	*1114*	*1114*	*1114*	*1114*	*1114*
Post-implant	*1114*	*1080*	*1049*	*1019*	*1002*	*976*	*955*

Number at risk

Pre-implant	*480*	*480*	*480*	*480*	*480*	*480*	*480*
Post-implant	*480*	*450*	*435*	*409*	*394*	*373*	*357*

Desai, A.S. et al. J Am Coll Cardiol. 2017;69(19):2357-65.

CARDIOMEMS IN HFrEF



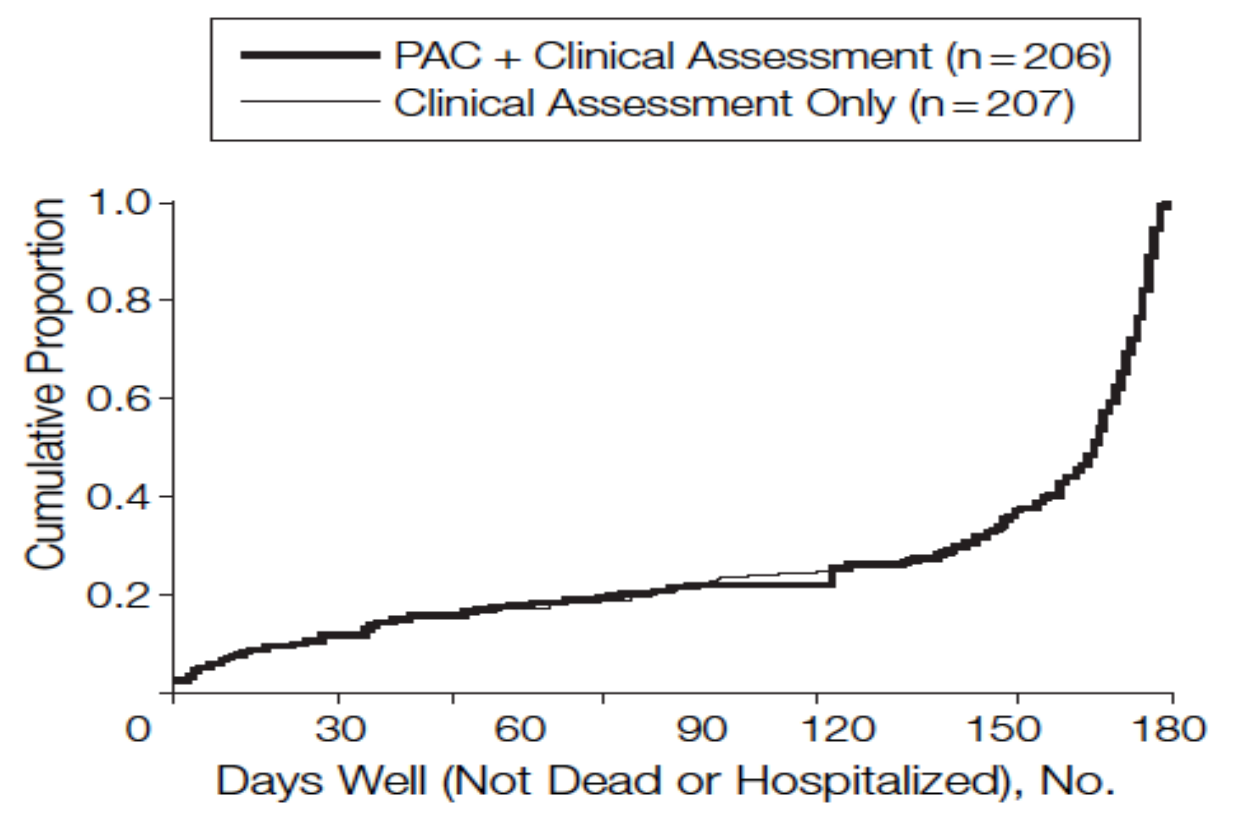
Givertz MM et al. JACC 2017

IMPLANTABLE HEMODYNAMIC MONITORING

- Monitoring significantly reduced the risk of HF-related hospitalization in patients w/ NYHA class III HF
- Implantation of device in PA is safe and free of major complications
- Useful for both systolic AND diastolic heart failure

Evaluation Study of Congestive Heart Failure and Pulmonary Artery Catheterization Effectiveness

The ESCAPE Trial



ESCAPE Investigators. JAMA 2005

CLINICAL CLASSIFICATION OF ADHF PATIENTS

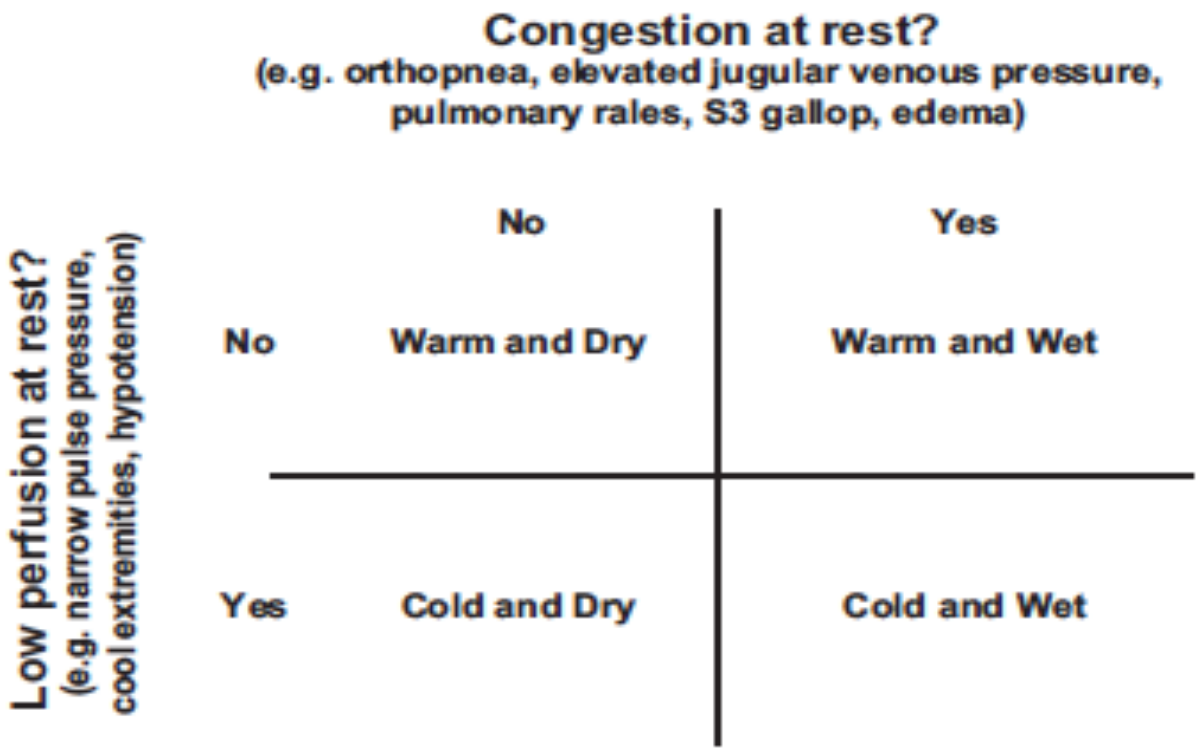
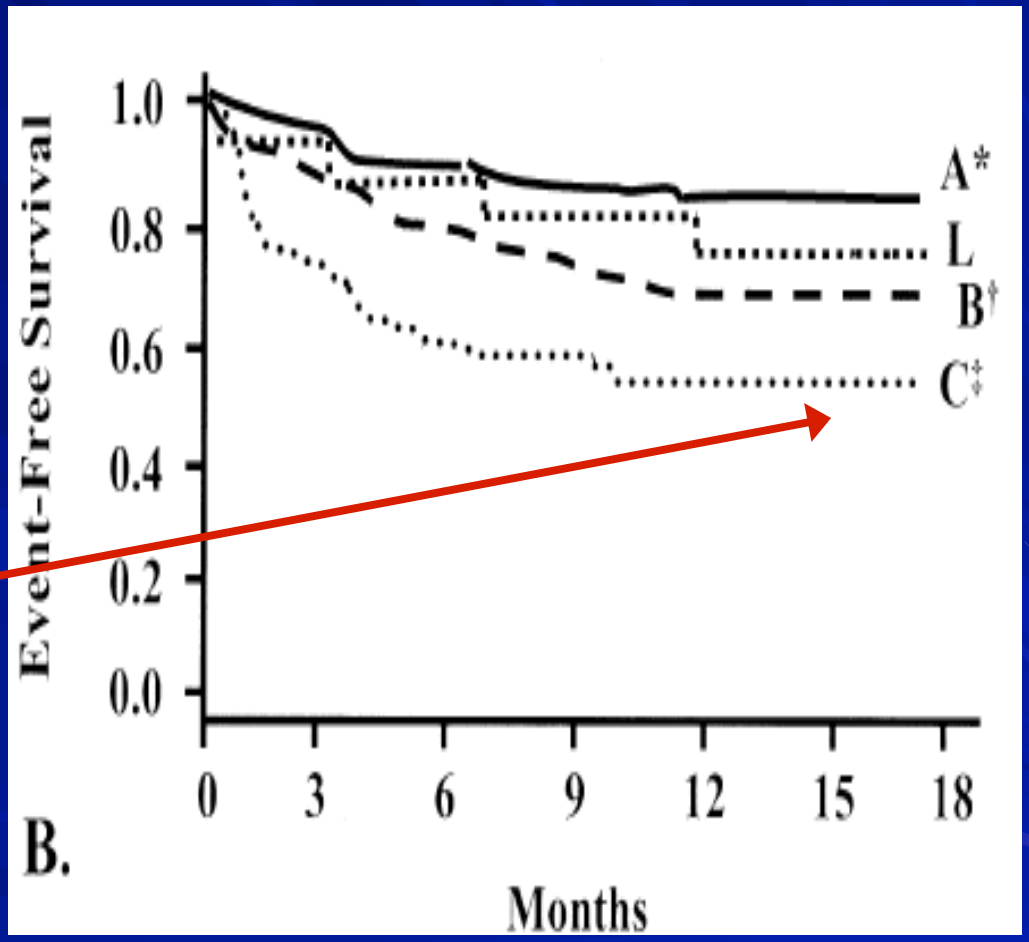


Figure 4. Classification of patients presenting with acutely decompensated heart failure. Adapted with permission from Nohria et al. (306).

Yancy CW et al. ACCF/AHA 2013 HF Guidelines

CLINICAL CLASSIFICATION OF ADHF PATIENTS

ADEQUATE PERFUSION	CONGESTION: --	CONGESTION: +
+	**A** *dry-warm* *(N=123)*	**B** *wet-warm* *(N=222)*
-	**L** *dry-cold* *(N=16)*	**C** *wet-cold* *(N=91)*



Nohria A et al. JACC 2003;1797-804

ADHF – ROLE OF PHYSICAL EXAMINATION

Table 3. Utility of Components of the H&P Examination in Detecting PCWP >22 mm Hg

				Predictive Value	
H&P Finding	Frequency	Sensitivity	Specificity	Positive	Negative
Rales (≥1/3 lung fields)	26/192	15	89	69	38
S3	123/192	62	32	61	33
Ascites (moderate/massive)	31/192	21	92	81	40
Edema (≥2+)	73/192	41	66	67	40
Orthopnea (≥2 pillows)	157/192	86	25	66	51
Hepatomegaly (>4 finger breadths)	23/191	15	93	78	39
Hepatojugular reflux	147/186	83	27	65	49
JVP ≥12 mm Hg	101/186	65	64	75	52
JVP <8 mm Hg	18/186	4.3	81	28	33

Drazner MH et al. Circ Heart Fail 2008;1:170-77.

HOW GOOD IS CLINICAL ASSESSMENT IN PREDICTING LOW CARDIAC INDEX (< 2.3 L/min/m2)?

				Predictive Value	
H&P Finding	Frequency	Sensitivity	Specificity	Positive	Negative
PPP<25%	16/188	10	96	87.5	28
SBP<100	75/188	42	66	77	29
SBP<90	25/188	12	84	68	26
Fatigue (at rest/any activity)	177/189	94	8	74	33
Cool extremities	34/189	20	88	82	28
"Cold" profile	52/188	33	86	86.5	32

Drazner MH et al. Circ Heart Fail 2009;1:170-77

INVASIVE HEMODYNAMIC MONITORING

Invasive hemodynamic monitoring should be considered in a patient:

- Who is refractory to initial therapy
- When volume status and cardiac filling pressures are unclear
- Who has clinically significant hypotension (typically SBP < 80 mmHg) or worsening renal failure during therapy,
- In whom documentation of an adequate hemodynamic response to the inotropic agent is necessary when chronic outpatient infusion is being considered.

Adams KF et al. *J Cardiac Failure* 2006;12:10-38.

INOTROPIC SUPPORT

Inotropic Agent	Dose (mcg/kg) Bolus	Dose (mcg/kg) Infusion (/min)	Drug Kinetics and Metabolism	Effects CO	Effects HR	Effects SVR	Effects PVR	Adverse Effects	Special Considerations
Adrenergic agonists									
Dopamine	N/A	5 to 10	$t_{1/2}$: 2 to 20 min R,H,P	↑	↑	↔	↔	T, HA, N, tissue necrosis	Caution: MAO-I
	N/A	10 to 15		↑	↑	↑	↔		
Dobutamine	N/A	2.5 to 5	$t_{1/2}$: 2 to 3 min H	↑	↑	↓	↔	↑/↓BP, HA, T, N, F, hypersensitivity	Caution: MAO-I; CI: sulfite allergy
	N/A	5 to 20		↑	↑	↔	↔		
PDE inhibitor									
Milrinone	N/R	0.125 to 0.75	$t_{1/2}$: 2.5 h H	↑	↑	↓	↓	T, ↓BP	Renal dosing, monitor LFTs

BP indicates blood pressure; CI, contraindication; CO, cardiac output; F, fever; H, hepatic; HA, headache; HF, heart failure; HR, heart rate; LFT, liver function test; MAO-I, monoamine oxidase inhibitor; N, nausea; N/A, not applicable; N/R, not recommended; P, plasma; PDE, phosphodiesterase; PVR, pulmonary vascular resistance; R, renal; SVR, systemic vascular resistance; T, tachyarrhythmias; and $t_{1/2}$, elimination half-life.

Yancy CW et al. 2013 ACCF/AHA HF Guidelines

INOTROPIC SUPPORT

- Preferable to start inotropic support following PA catheter placement to document low cardiac index
- If BP is adequate on inotropic support, can up-titrate guideline-directed medical therapy and attempt weaning at a future date
- Encourage referral to advanced heart failure / VAD / transplant program